U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NUREG-XXXX

U.S. NRC Level 3 Probabilistic Risk Assessment Project

Volume 5c: Reactor, At-Shutdown, Level 3 PRA for Internal Events

This report, though formatted as a NUREG report, is currently being released as a draft (non-NUREG) technical report.

Office of Nuclear Regulatory Research

AVAILABILITY OF REFERENCE MATERIALS IN NRC PUBLICATIONS

NRC Reference Material

As of November 1999, you may electronically access NUREG-series publications and other NRC records at the NRC's Public Electronic Reading Room at http://www.nrc.gov/reading-rm.html. Publicly released records include, to name a few, NUREG-series publications; *Federal Register* notices; applicant, licensee, and vendor documents and correspondence; NRC correspondence and internal memoranda; bulletins and information notices; inspection and investigative reports; licensee event reports; and Commission papers and their attachments.

NRC publications in the NUREG series, NRC regulations, and Title 10, "Energy," in the *Code of Federal Regulations* may also be purchased from one of these two sources.

1. **The Superintendent of Documents**
   U.S. Government Publishing Office
   Mail Stop SSOP
   Washington, DC 20402-0001
   Internet: http://bookstore.gpo.gov
   Telephone: 1-866-512-1800
   Fax: (202) 512-2104

2. **The National Technical Information Service**
   5301 Shawnee Road
   Alexandria, VA 22161-0002
   http://www.ntis.gov
   1-800-553-6847 or, locally, (703) 605-6000

A single copy of each NRC draft report for comment is available free, to the extent of supply, upon written request as follows:

U.S. Nuclear Regulatory Commission
Office of Administration
Publications Branch
Washington, DC 20555-0001
E-mail: distribution.resource@nrc.gov
Facsimile: (301) 415-2289

Some publications in the NUREG series that are posted at the NRC's Web site address http://www.nrc.gov/reading-rm/doc-collections/nuregs are updated periodically and may differ from the last printed version. Although references to material found on a Web site bear the date the material was accessed, the material available on the date cited may subsequently be removed from the site.

Non-NRC Reference Material

Documents available from public and special technical libraries include all open literature items, such as books, journal articles, transactions, *Federal Register* notices, Federal and State legislation, and congressional reports. Such documents as theses, dissertations, foreign reports and translations, and non-NRC conference proceedings may be purchased from their sponsoring organization.

Copies of industry codes and standards used in a substantive manner in the NRC regulatory process are maintained at—

The NRC Technical Library
Two White Flint North
11545 Rockville Pike
Rockville, MD 20852-2738

These standards are available in the library for reference use by the public. Codes and standards are usually copyrighted and may be purchased from the originating organization or, if they are American National Standards, from—

American National Standards Institute
11 West 42nd Street
New York, NY 10036-8002
http://www.ansi.org
(212) 642-4900

Legally binding regulatory requirements are stated only in laws; NRC regulations; licenses, including technical specifications; or orders, not in NUREG-series publications. The views expressed in contractor-prepared publications in this series are not necessarily those of the NRC.

The NUREG series comprises (1) technical and administrative reports and books prepared by the staff (NUREG-XXXX) or agency contractors (NUREG/CR-XXXX), (2) proceedings of conferences (NUREG/CP-XXXX), (3) reports resulting from international agreements (NUREG/IA-XXXX), (4) brochures (NUREG/BR-XXXX), and (5) compilations of legal decisions and orders of the Commission and Atomic and Safety Licensing Boards and of Directors' decisions under Section 2.206 of NRC's regulations (NUREG-0750).

DISCLAIMER: This report was prepared as an account of work sponsored by an agency of the U.S. Government. Neither the U.S. Government nor any agency thereof, nor any employee, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for any third party's use, or the results of such use, of any information, apparatus, product, or process disclosed in this publication, or represents that its use by such third party would not infringe privately owned rights.

NUREG-XXXX

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

U.S. NRC Level 3 Probabilistic Risk Assessment Project

Volume 5c: Reactor, At-Shutdown, Level 3 PRA for Internal Events

Manuscript Completed: Month 2025
Date Published: September 2025

Prepared by:
K. Compton,[1] A. Hathaway,[1] and A. Kuritzky[2]

[1] Formerly with the U.S. Nuclear Regulatory Commission

[2] U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

A. Kuritzky, NRC Level 3 PRA Project Program Manager

Office of Nuclear Regulatory Research

ABSTRACT

The U.S. Nuclear Regulatory Commission performed a full-scope site Level 3 probabilistic risk assessment (PRA) project (L3PRA project) for a two-unit pressurized-water reactor reference plant. The scope of the L3PRA project encompasses all major radiological sources on the site (i.e., reactors, spent fuel pools, and dry cask storage), all internal and external hazards, and all modes of plant operation. A full-scope site Level 3 PRA for a nuclear power plant site can provide valuable insights into the importance of various risk contributors by assessing accidents involving one or more reactor cores as well as other site radiological sources. This report, one of a series of reports documenting the models and analyses supporting the L3PRA project, specifically addresses the reactor, at-shutdown, Level 3 PRA model for internal events for a single unit. The analyses documented herein are based information for the reference plant as it was designed and operated as of 2012 and does not reflect the plant as it is currently designed, licensed, operated, or maintained.[1]

CAUTION: The L3PRA project was developed to meet the specific objectives outlined in SECY-11-0089 using state of practice methods and data. While the study provides valuable insights and addresses its key objectives, due to limitations in time, resources, and plant information, some technical aspects of the study were subjected to simplifications or were not fully addressed. As such, inclusion of approaches in the L3PRA project documentation should ***not*** be viewed as an endorsement of these approaches for regulatory purposes.

[1] An overview report, which covers all three PRA levels, has been created for each major element of the L3PRA project scope (e.g., for the combined internal event and internal flood PRAs for a single reactor unit operating at full power). These overview reports include a reevaluation of plant risk based on a set of updated plant equipment and PRA model assumptions (e.g., incorporation of the current reactor coolant pump shutdown seal design at the reference plant and the potential impact of the U.S. nuclear power industry's proposed safety strategy, called Diverse and Flexible Coping Strategies [FLEX], both of which reduce the risk to the public).

FOREWORD

The U.S. Nuclear Regulatory Commission (NRC) performed a full-scope site Level 3 probabilistic risk assessment (PRA) project (L3PRA project) for a two-unit pressurized-water reactor reference plant. The staff undertook this project in response to Commission direction in the staff requirements memorandum dated September 21, 2011 (Agencywide Documents and Management System [ADAMS] Accession No. ML112640419) resulting from SECY-11-0089, "Options for Proceeding with Future Level 3 Probabilistic Risk Assessment Activities," dated July 7, 2011 (ML11090A039).

Licensee information used in performing the Level 3 PRA project was voluntarily provided based on a licensed, operating nuclear power plant. The information provided reflects the plant as it was designed and operated as of 2012 and does not reflect the plant as it is currently designed, licensed, operated, or maintained. In addition, the information provided for the reference plant was changed based on additional information, assumptions, practices, methods, and conventions used by the NRC in the development of plant-specific PRA models used in its regulatory decision-making. **As such, the L3PRA project reports will not be the sole basis for any regulatory decisions specific to the reference plant.**

Each set of L3PRA project reports covering the Level 1, 2, and 3 PRAs for a specific site radiological source, plant operating state, and hazard group is accompanied by an overview report. The overview reports summarize the results and insights from all three PRA levels.

To provide results and insights better aligned with the current design and operation of the reference plant, the overview reports also provide the results of a parametric sensitivity analysis based on a set of new plant equipment and PRA model assumptions for all three PRA levels. The sensitivity analysis reflects the current reactor coolant pump shutdown seal design at the reference plant, as well as the potential impact of FLEX strategies,[1] both of which reduce the risk to the public.

A full-scope site Level 3 PRA for a nuclear power plant site can provide valuable insights into the importance of various risk contributors by assessing accidents involving one or more reactor cores as well as other site radiological sources (i.e., spent fuel in pools and dry storage casks). These insights may be used to further enhance the regulatory framework and decision-making and to help focus limited agency resources on issues most directly related to the agency's mission to protect public health and safety. More specifically, potential future uses of the L3PRA project can be categorized as follows (a more detailed list is provided in SECY-12-0123, "Update on Staff Plans to Apply the Full-Scope Site Level 3 PRA Project Results to the NRC's Regulatory Framework," dated September 13, 2012 [ML12202B170]):

- enhancing the technical basis for the use of risk information (e.g., obtaining updated and enhanced understanding of plant risk as compared to the Commission's safety goals)

[1] FLEX refers to the U.S. nuclear power industry's proposed safety strategy, called Diverse and Flexible Coping Strategies. FLEX is intended to maintain long-term core and spent fuel cooling and containment integrity with installed plant equipment that is protected from natural hazards, as well as backup portable onsite equipment. If necessary, similar equipment can be brought from off site.

- improving the PRA state of practice (e.g., demonstrating new methods for site risk assessments, which may be particularly advantageous in addressing the risk from advanced reactor designs, a multi-unit accident, or an accident involving spent fuel; and using PRA information to inform emergency planning)

- identifying safety and regulatory improvements (e.g., identifying potential safety improvements that may lead to either regulatory improvements or voluntary implementation by licensees)

- supporting knowledge management (e.g., developing or enhancing in-house PRA technical capabilities)

In addition, the overall L3PRA project model can be exercised to provide insights regarding other issues not explicitly included in the current project scope (e.g., security-related events or the use of accident tolerant fuel). Furthermore, some future advanced light water reactor (ALWR) and advanced non-light water reactor (NLWR) applicants may rely heavily on the results of analyses similar to those used in the L3PRA project to establish their licensing basis and design basis by using the Licensing Modernization Project (LMP) (NEI 18-04, Rev. 1) which was endorsed via Regulatory Guide 1.233 in June 2020. Licensees who use the LMP framework are required to perform Level 3 PRA analyses. Therefore, another potential use of the methodology and insights generated from this study is to inform regulatory, policy, and technical issues pertaining to ALWRs and NLWRs.

The results and perspectives from this report, as well as all other reports prepared in support of the L3PRA project, will be incorporated into a summary report to be published after all technical work for the L3PRA project has been completed.

TABLE OF CONTENTS

ABSTRACT ..... **iii**

FOREWORD ..... **v**

TABLE OF CONTENTS ..... **vii**

LIST OF FIGURES ..... **xi**

LIST OF TABLES ..... **xvii**

EXECUTIVE SUMMARY ..... **xxiii**

ACKNOWLEDGMENTS ..... **xxix**

ABBREVIATIONS AND ACRONYMS ..... **xxxi**

1 INTRODUCTION **1-1**
1.1 Documentation 1-3
1.2 Relationship to ASME/ANS Level 3 PRA Standard 1-4
1.3 Identification and Treatment of Uncertainties 1-5

2 BACKGROUND AND GENERAL INFORMATION **2-1**
2.1 The MACCS Probabilistic Offsite Consequence Analysis Code 2-1
2.2 General Site Information 2-1

3 INPUT DATA **3-1**
3.1 Radionuclide Release Characterization for Level 3 (RE) 3-1
3.1.1 Assumptions and Known Limitations 3-1
3.1.2 Technical Discussion 3-2
3.1.3 MACCS Radionuclide Release Input Parameter Summary 3-33
3.1.4 Identification and Discussion of Uncertainties Related to Radionuclide Release Characterization 3-34
3.2 Meteorological Data (ME) 3-41
3.2.1 Assumptions and Known Limitations 3-41
3.2.2 Technical Discussion 3-41
3.2.3 MACCS Meteorological Input Parameter Summary 3-41
3.2.4 Identification and Discussion of Uncertainties Related to Meteorological Data 3-42
3.3 Atmospheric Transport and Dispersion (ATD) 3-48
3.3.1 Assumptions and Known Limitations 3-48
3.3.2 Technical Discussion 3-49
3.3.3 MACCS Atmospheric Transport and Deposition Input Parameter Summary 3-52
3.3.4 Identification and Discussion of Uncertainties Related to Atmospheric Transport and Dispersion 3-55
3.4 Protective Action Parameters and Other Site Data (PA) and Economic Factors (EC) 3-62
3.4.1 Assumptions and Known Limitations 3-62
3.4.2 Technical Discussion 3-64
3.4.3 MACCS Protective Action/Economic Cost Input Parameter Summary 3-77
3.4.4 Identification and Discussion of Uncertainties Related to Protective Actions Parameters, Site Data, and Economic Factors 3-83
3.5 Dosimetry (DO) 3-92
3.5.1 Assumptions and Known Limitations 3-92

3.5.2 Technical Discussion 3-92
3.5.3 MACCS Dosimetry Input Parameter Summary....3-93
3.5.4 Identification and Discussion of Uncertainties Related to Dosimetry....3-93
3.6 Health Effects (HE) 3-95
3.6.1 Assumptions and Known Limitations 3-95
3.6.2 Technical Discussion 3-96
3.6.3 MACCS Health Effects Input Parameter Summary....3-96
3.6.4 Identification and Discussion of Uncertainties Related to Health Effects Modeling....3-99
3.7 Output Control....3-103

4 RESULTS 4-1
4.1 Doses to the Offsite Public 4-11
4.1.1 Sensitivity Cases....4-22
4.2 Early Health Effects....4-31
4.2.1 Sensitivity Cases....4-40
4.3 Latent Health Effects....4-44
4.3.1 Total Latent Fatalities (MACCS Type 1) 4-45
4.3.2 Population-Weighted Individual Latent Fatality Risk (MACCS Type 8) 4-51
4.3.3 Sensitivity Cases....4-60
4.4 Land Contamination 4-72
4.4.1 Sensitivity Cases....4-79
4.5 Affected Population 4-85
4.5.1 Sensitivity Cases....4-98
4.6 Economic Costs 4-104
4.6.1 Sensitivity Cases....4-117
4.7 Results Summary....4-123

5 RISK INTEGRATION 5-1
5.1 Doses to the Offsite Public 5-2
5.1.1 CCDF Curves and Summary Tables of Exceedance Frequencies 5-2
5.1.2 Significant Contributors to Risk 5-4
5.2 Early Health Effects....5-6
5.2.1 CCDF Curves and Summary Tables of Exceedance Frequencies 5-6
5.2.2 Significant Contributors to Risk 5-9
5.3 Latent Health Effects....5-9
5.3.1 CCDF Curves and Summary Tables of Exceedance Frequencies 5-10
5.3.2 Significant Contributors to Risk 5-13
5.4 Land Contamination 5-15
5.4.1 CCDF Curves and Summary Tables of Exceedance Frequencies 5-16
5.4.2 Significant Contributors to Risk 5-18
5.5 Affected Population 5-19
5.5.1 CCDF Curves and Summary Tables of Exceedance Frequencies 5-20
5.5.2 Significant Contributors to Risk 5-22
5.6 Economic Costs 5-23
5.6.1 CCDF Curves and Summary Tables of Exceedance Frequencies 5-24
5.6.2 Significant Contributors to Risk 5-26
5.7 Risk Integration Summary....5-27

6 MODEL ERRORS AND POTENTIAL CANDIDATES FOR FUTURE WORK 6-1

7 REFERENCES....7-1

APPENDIX A MACCS PLUME SEGMENT DEFINITIONS.....Error! Bookmark not defined.

[Note: Due to word-processing software limitations, hyperlinks between the main report and the appendix are not functional.]

LIST OF FIGURES

Figure 3-1 Relative Contribution of Release Categories to Frequency-Weighted Mean Cesium Release Magnitude 3-18

Figure 3-2 Relative Contribution of Release Categories to Frequency-Weighted Mean Iodine Release Magnitude....3-18

Figure 3-3 Cesium Release Magnitude as a Function of (a) Time since Shutdown, (b) Time since Initiating Event, and (c) Time since GE Declaration 3-21

Figure 3-4 Iodine Release Magnitude as a Function of (a) Time since Shutdown, (b) Time since Initiating Event, and (c) Time since GE Declaration 3-22

Figure 3-5 Comparison of MELCOR and MelMACCS Post-Processed Release Fraction Profiles for SD01-2 (ECF) 3-75

Figure 3-6 Comparison of MELCOR and MelMACCS Post-Processed Release Fraction Profiles for SD01-8 (ICF-BURN)....3-75

Figure 4-1 Relative Contribution of Release Categories to Frequency-Weighted Cumulative Cesium Release Fraction: Base Case vs. RE_4....4-10

Figure 4-2 Conditional Mean Value (Across All Weather Trials) of Peak Total Effective Dose (rem) from Early-Phase Exposure to the Non-Evacuating Cohort....4-13

Figure 4-3 Conditional Mean Value (Across All Weather Trials) of Peak Total Effective Dose (rem) from Late-Phase Exposure 4-13

Figure 4-4 Annual Frequency of Exceeding a Specified Dose Level (rem/rad-eq) from Early-Phase Exposure to the Non-Evacuating Cohort....4-14

Figure 4-5 Annual Frequency of Exceeding a Specified Dose Level (rem) from Late-Phase Exposure 4-14

Figure 4-6 Relative Contribution of Release Categories to Mean (Over All Weather Trials) Collective Total Effective Dose, Overall, 50 Miles....4-19

Figure 4-7 Relative Contribution of Release Categories to Mean (Over All Weather Trials) Collective Total Effective Dose, Overall, 100 Miles....4-19

Figure 4-8 Conditional Mean (Across All Weather Trials) Collective Total Effective Dose within 50 and 100 Miles as a Function of Cesium Release Magnitude....4-20

Figure 4-9 Complementary Cumulative Distribution Function of Collective Total Effective Dose, 0–50 Miles (person-rem) 4-21

Figure 4-10 Complementary Cumulative Distribution Function of Collective Total Effective Dose, 0–100 Miles (person-rem) 4-21

Figure 4-11 Relative Contribution of Release Categories to Overall Mean Collective Total Effective Dose, 0–50 Miles: RE_4 4-29

Figure 4-12 Relative Contribution of Release Categories to Overall Mean Collective Effective Dose, 0–100 Miles: RE_4 4-30

Figure 4-13 Relative Contribution of Weather Bins and Release Categories to Mean (Across All Weather Trials) Total Early Fatality Cases 4-36

Figure 4-14 Relative Contribution of Weather Bins and Release Categories to Conditional Mean (Across All Weather Trials) Population-Weighted Individual Early Fatality Risk 4-37
Figure 4-15 Complementary Cumulative Distribution Function of Total Early Fatality Cases within 50 Miles 4-39
Figure 4-16 Complementary Cumulative Distribution Function of Population-Weighted Individual Early Fatality Risk within 1 Mile of Site Boundary 4-39
Figure 4-17 Total Latent Fatalities as a Function of Cesium Release Magnitude, LPSD and IEIF Release Categories 4-47
Figure 4-18 Ratio of Latent Fatality Cases Between 50 and 100 Miles as a Function of Cesium Release Magnitude 4-48
Figure 4-19 Contribution of Release Categories to Conditional Mean (Across All Weather Trials) Total Latent Fatality Cases within 50 Miles 4-49
Figure 4-20 Contribution of Release Categories to Conditional Mean (Across All Weather Trials) Total Latent Fatality Cases within 100 Miles 4-49
Figure 4-21 Complementary Cumulative Distribution Function, Latent Fatality Cases, 0–50 Miles 4-50
Figure 4-22 Complementary Cumulative Distribution Function, Latent Fatality Cases, 0–100 Miles 4-51
Figure 4-23 Conditional Mean (Across All Weather Trials) Population-Weighted Individual Latent Fatality Risk within 10 Miles by Release Category and Accident Phase 4-54
Figure 4-24 Conditional Mean (Across All Weather Trials) Early- and Late-Phase Population-Weighted Individual Latent Fatality Risk within 10 Miles as a Function of Cesium Release Magnitude 4-55
Figure 4-25 Relative Contribution of the Individual Release Categories to Conditional Mean (Across All Weather Trials) Population-Weighted Individual Latent Fatality Risk within 10 Miles 4-56
Figure 4-26 Complementary Cumulative Distribution Function, Population-Weighted Individual Latent Fatality Risk within 10 Miles 4-58
Figure 4-27 Complementary Cumulative Distribution Function, Population-Weighted Individual Latent Fatality Risk within 10 Miles: Frequency-Weighted for Each Source Term and Population-Weighted by Individual Cohort Populations 4-58
Figure 4-28 Complementary Cumulative Distribution Function, Population-Weighted Individual Latent Fatality Risk within 10 Miles: Frequency-Weighted for Each Source Term and Population-Weighted by All Cohort Populations 4-59
Figure 4-29 Relative Contribution of Release Categories to Population-Weighted Individual Latent Fatality Risk within 10 Miles: RE_4 4-66
Figure 4-30 Relative Contribution of Release Categories to Population-Weighted Individual Latent Fatality Risk within 10 Miles: HE_2 4-71

Figure 4-31 Relative Contribution of Release Categories to the Frequency-Weighted Mean Value of Land Exceeding a Deposition of 555 kBq/m^2 (15 Ci/km^2) within 50 Miles 4-75

Figure 4-32 Relative Contribution of Release Categories to the Frequency-Weighted Mean Value of Land Exceeding a Deposition of 555 kBq/m^2 (15 Ci/km^2) within 100 Miles 4-76

Figure 4-33 Conditional Mean (Across All Weather Trials) Area within 100 Miles Exceeding a Cs-137 Deposition of 1.5 MBq/m^2 (40 Ci/km^2) and 555 kBq/m^2 (15 Ci/km^2) as a Function of Cesium Release Magnitude 4-77

Figure 4-34 Complementary Cumulative Distribution Function, Land Area (mi^2) Exceeding 555 kBq/m^2 (1.50E-05 Ci/m^2) Cs-137 within 50 Miles 4-78

Figure 4-35 Complementary Cumulative Distribution Function, Land Area (mi^2) Exceeding 555 kBq/m^2 (1.50E-05 Ci/m^2) Cs-137 within 100 Miles 4-78

Figure 4-36 Relative Contribution of Release Categories to Land Area (mi^2) Exceeding 555 kBq/m^2 (15 Ci/km^2) Cs-137, 0–50 miles: RE_4 4-83

Figure 4-37 Relative Contribution of Release Categories to Land Area (mi^2) Exceeding 555 kBq/m^2 (15 Ci/km^2) Cs-137, 0–100 Miles: RE_4 4-84

Figure 4-38 Conditional Mean (Across All Weather Trials) Size of Population Subject to Early- and Late-Phase Relocation as a Function of Cesium Release Magnitude 4-91

Figure 4-39 Conditional Mean (Across All Weather Trials) Size of Population Subject to Intermediate-Phase Relocation within 50 and 100 Miles as a Function of Cesium Release Magnitude 4-92

Figure 4-40 Contribution of Release Categories to Conditional Mean (Across All Weather Trials) Early-Phase Affected Population Size within 100 Miles....4-94

Figure 4-41 Contribution of Release Categories to Conditional Mean (Across All Weather Trials) Combined Intermediate- and Recovery-Phase Affected Population Size within 100 Miles....4-94

Figure 4-42 Contribution of Release Categories to Conditional Mean (Across All Weather Trials) Intermediate-Phase-Affected Population Size within 50 Miles 4-95

Figure 4-43 Contribution of Release Categories to Conditional Mean (Across All Weather Trials) Intermediate-Phase-Affected Population Size within 100 Miles 4-95

Figure 4-44 Complementary Cumulative Distribution Function of Population Subject to Intermediate-Phase Relocation within 50 Miles....4-97

Figure 4-45 Complementary Cumulative Distribution Function of Population Subject to Intermediate-Phase Relocation within 100 Miles....4-97

Figure 4-46 Relative Contribution of Release Categories to Population Relocated during Intermediate Phase, 0–50 Miles (Persons): RE_4....4-102

Figure 4-47 Relative Contribution of Release Categories to Population Relocated during Intermediate Phase, 0–100 Miles (Persons): RE_4....4-103

Figure 4-48 Relative Contribution of Protective Actions to Conditional Mean (Over All Weather Trials) Total Frequency-Weighted Economic Costs within 50 Miles 4-110
Figure 4-49 Relative Contribution of Protective Actions to Conditional Mean (Over All Weather Trials) Total Frequency-Weighted Economic Costs within 100 Miles 4-110
Figure 4-50 Relative Contribution of Release Categories to Conditional Mean (Over All Weather Trials) Total Frequency-Weighted Economic Costs within 50 Miles 4-111
Figure 4-51 Relative Contribution of Release Categories to Conditional Mean (Over All Weather Trials) Total Frequency-Weighted Economic Costs within 100 Miles 4-111
Figure 4-52 Conditional Mean (Over All Weather Trials) Total Economic Costs (2015$) within 50 and 100 Miles as a Function of Cesium Release Magnitude 4-113
Figure 4-53 Conditional Mean (Over All Weather Trials) Total Economic Costs (2015$) by Type within 100 Miles as a Function of Cesium Release Magnitude 4-114
Figure 4-54 Complementary Cumulative Distribution Function of Total Economic Costs within 50 Miles 4-116
Figure 4-55 Complementary Cumulative Distribution Function of Total Economic Costs within 100 Miles 4-116
Figure 4-56 Relative Contribution of Release Categories to Total Economic Costs, 0–50 Miles (2015$): RE_4 4-121
Figure 4-57 Relative Contribution of Release Categories to Total Economic Costs, 0–100 Miles (2015$): RE_4 4-122
Figure 5-1 CCDF Curves of Uncertain Collective Total Effective Dose within the 0–50-Mile Interval (person-rem) 5-3
Figure 5-2 CCDF Curves of Uncertain Collective Total Effective Dose Within the 0–100-Mile Interval (person-rem) 5-3
Figure 5-3 CCDF Curves of Uncertain Population-Weighted Individual Early Fatality Risk Within 1 Mile of the Site Boundary 5-7
Figure 5-4 CCDF Curves of Uncertain Total Early Fatalities within 50 Miles 5-7
Figure 5-5 CCDF Curves of Uncertain Individual Latent Fatality Risk within 10 Miles 5-11
Figure 5-6 CCDF Curves of Uncertain Total Latent Fatality Cases within the 0–50-Mile Interval 5-12
Figure 5-7 CCDF Curves of Uncertain Total Latent Fatality Cases within the 0–100-Mile Interval 5-12
Figure 5-8 CCDF Curves for Uncertain Land Area (mi^2) Exceeding a Deposition of 555 kBq/m^2 (15 Ci/km^2) within the 0–50-Mile Interval 5-17
Figure 5-9 CCDF Curves for Uncertain Land Area (mi^2) Exceeding a Deposition of 555 kBq/m^2 (15 Ci/km^2) within the 0–100-Mile Interval 5-17

Figure 5-10 CCDF Curves of Uncertain Intermediate Phase Relocation Population within the 0–50-Mile Interval 5-21
Figure 5-11 CCDF Curves of Uncertain Intermediate Phase Relocation Population within the 0–100-Mile Interval 5-21
Figure 5-12 CCDF Curves of Uncertain Total Economic Costs within the 0–50-Mile Interval....5-25
Figure 5-13 CCDF Curves of Uncertain Total Economic Costs within the 0–100-Mile Interval....5-25

LIST OF TABLES

Table 1-1 Relationship of Technical Elements from the Draft Level 3 PRA Standard to this Report 1-5

Table 3-1 Summary of Release Categories from Level 2 Analysis 3-4

Table 3-2 Description of Representative Sequences and Permutations 3-6

Table 3-3 Preliminary Reactor-At-Shutdown EAL Classifications 3-8

Table 3-4 Comparison of Preliminary GE Time to Release Timings 3-13

Table 3-5 Release Category Summary Table for the Level 3 PRA Team 3-15

Table 3-6 Cumulative Release of Cesium (Cs) and Iodine (I) Classes at the End of the Simulation 3-17

Table 3-7 Initial Core Inventories (Bq) 3-24

Table 3-8 Description of Release Points from MELCOR Modeling 3-27

Table 3-9 Summary of MACCS Source Terms 3-31

Table 3-10 Summary of Key Event Timings for MACCS Source Terms 3-32

Table 3-11 Summary of MACCS Inputs Related to Radionuclide Release Characterization 3-33

Table 3-12 Uncertainties Related to Radionuclide Release Characterization 3-36

Table 3-13 Potential Sensitivity Analyses to Address Uncertainties Related to Radionuclide Release Characterization 3-39

Table 3-14 Summary of MACCS Input Parameters Related to Meteorological Data 3-42

Table 3-15 Uncertainties Related to Meteorological Data 3-44

Table 3-16 Potential Sensitivity Analyses to Address Uncertainties Related to Meteorological Data 3-47

Table 3-17 Release Path Parameters for Dispersion Modeling 3-50

Table 3-18 Release Path Modeled, by Source Term 3-52

Table 3-19 Summary of MACCS Input Parameters Related to Atmospheric Transport and Deposition 3-53

Table 3-20 Log-Triangular Values for Dispersion Parameters CYSIGA and CZSIGA 3-56

Table 3-21 Uncertainties Related to Atmospheric Transport and Dispersion 3-58

Table 3-22 Potential Sensitivity Analyses to Address Uncertainties Related to Atmospheric Transport and Dispersion 3-60

Table 3-23 Sequence-Specific Intermediate-Phase Durations 3-66

Table 3-24 Identification of Base-Case Emergency-Response Models 3-67

Table 3-25 Emergency-Response Template 3-68

Table 3-26 Case-Specific Declaration Times for Model Expansions 3-69

Table 3-27 DLTSHL (hr) for EP Model 1 Cohorts 3-70

Table 3-28 DLTSHL (hr) for Additional Cohorts for EP Model 2 3-71
Table 3-29 DLTSHL (hr) for Additional Cohorts for EP Model 3 3-72
Table 3-30 KI, Sheltering, and Evacuation Parameters....3-73
Table 3-31 Recommended Early-Phase Relocation Timing 3-74
Table 3-32 Early-Phase Relocation Parameters 3-76
Table 3-33 Summary of MACCS Input Parameters Related to Protective Action Parameters, Site Data, and Economic Factors....3-78
Table 3-34 Uncertainties Related to Protective Action Parameters, Site Data, and Economic Factors 3-85
Table 3-35 Potential Sensitivity Analyses to Address Uncertainties in Protective Action Parameters, Site Data, and Economic Factors....3-90
Table 3-36 Summary of MACCS Input Parameters Related to Dosimetry....3-93
Table 3-37 Uncertainties Related to Dosimetry....3-94
Table 3-38 Potential Sensitivity Analyses to Address Uncertainties Related to Dosimetry 3-95
Table 3-39 Summary of MACCS Input Parameters Related to Health Effects....3-96
Table 3-40 Uncertainties Related to Health Effects Modeling....3-101
Table 3-41 Potential Sensitivity Analyses to Address Uncertainties Related to Health Effects....3-102
Table 3-42 Parameters for the 10 mrem Annual Threshold Latent-Cancer Quantification Model 3-103
Table 3-43 Parameters for the HPS Threshold Latent-Cancer Quantification Model....3-103
Table 4-1 Summary of Dose Measures (Conditional Mean Value Across All Weather Trials)....4-3
Table 4-2 Summary of Early Health Effect Measures (Conditional Mean Value Across All Weather Trials)....4-4
Table 4-3 Summary of Latent Health Effect Measures (Conditional Mean Value Across All Weather Trials)....4-5
Table 4-4 Summary of Land Contamination, Affected Population, and Economic Cost Measures (Conditional Mean Value Across All Weather Trials) 4-6
Table 4-5 Truncated Cumulative Release Fractions at 36 Hours after SAMG Entry (RE_4) Compared to Untruncated Cumulative Release Fractions (ME_2) 4-8
Table 4-6 Summary of Population Exceeding Dose (Conditional Mean Value Across All Weather Trials) 4-12
Table 4-7 Summary of Collective Total Effective Dose (Conditional Mean Value Across All Weather Trials)....4-15
Table 4-8 Conditional Mean (Across All Weather Trials) Collective Total Effective Dose (Person-Rem) by Cohort Type within 50 Miles....4-16

Table 4-9 Conditional Mean (Across All Weather Trials) Collective Total Effective Dose (Person-Rem) by Cohort Type within 100 Miles 4-17

Table 4-10 Conditional Mean (Across All Weather Trials) Collective Total Effective Dose (Person-Rem), 0–50 Miles: ME_2 4-22

Table 4-11 Conditional Mean (Across All Weather Trials) Collective Total Effective Dose (Person-Rem), 0–100 Miles: ME_2 4-23

Table 4-12 Conditional Mean (Across All Weather Trials) Population Exceeding Early-Phase Total Effective Dose of 10 Rem (Persons): ME_2 4-23

Table 4-13 Conditional Mean (Across All Weather Trials) Population Exceeding Early-Phase Acute Red Bone Marrow Dose of 10 Rad-Eq (Persons): ME_2 4-24

Table 4-14 Conditional Mean (Across All Weather Trials) Collective Total Effective Dose (Person-Rem), 0–50 Miles: RE_4 4-25

Table 4-15 Conditional Mean (Across All Weather Trials) Collective Total Effective Dose (Person-Rem), 0–100 Miles: RE_4 4-26

Table 4-16 Conditional Mean (Across All Weather Trials) Population Exceeding Early-Phase Total Effective Dose Of 10 Rem (Persons): RE_4 4-27

Table 4-17 Conditional Mean (Across All Weather Trials) Population Exceeding Early-Phase Acute Red Bone Marrow Dose Of 10 Rad-Eq (Persons): RE_4 4-28

Table 4-18 Conditional Mean (Across All Weather Trials) Number of Early Fatality Cases Within 50 Miles, by Release Category and Cohort Type 4-32

Table 4-19 Conditional Mean (Across All Weather Trials) Number of Early Injury (Prodromal Vomiting) Cases within 50 Miles, by Release Category and Cohort Type 4-33

Table 4-20 Conditional Mean (Across All Weather Trials) Value of Individual Early Fatality Risk, by Release Category and Cohort Type 4-34

Table 4-21 Range in Miles at Which Early Fatality Risk >0 for Non-Evacuating and 10-Mile Tail Cohorts, Conditional Mean and 95th Percentile Across All Weather Trials 4-35

Table 4-22 Individual Early Fatality Risk, 0–1.8 Miles (Mean Value Across All Weather Trials): ME_2 4-40

Table 4-23 Early Fatality Cases, 0–50 Miles (Persons) (Conditional Mean Value Across All Weather Trials): ME_2 4-41

Table 4-24 Early Injury (Prodromal Vomiting) Cases, 0–50 Miles (Persons) (Conditional Mean Value Across All Weather Trials): ME_2 4-41

Table 4-25 Individual Early Fatality Risk, 0–1.8 Miles (Conditional Mean Value Across All Weather Trials): RE_4 4-42

Table 4-26 Early Fatality Cases, 0–50 Miles, Persons (Conditional Mean Value Across All Weather Trials): RE_4 4-43

Table 4-27 Early Injury (Prodromal Vomiting) Cases, 0–50 Miles, Persons (Conditional Mean Value Across All Weather Trials): RE_4 4-44

Table 4-28 Conditional Mean (Across All Weather Trials) Number of Latent Fatality Cases within 50 Miles by Cohort Type 4-46

Table 4-29 Conditional Mean (Across All Weather Trials) Number of Latent Fatality Cases within 100 Miles by Cohort Type 4-46

Table 4-30 Conditional Mean (Across All Weather Trials) Value of the Population-Weighted Individual Latent Cancer Fatality Risk within 10 Miles, by Release Category and Cohort....4-53

Table 4-31 Population-Weighted Individual Latent Fatality Risk, 0–10 Miles (Conditional Mean Value Across All Weather Trials): ME_2....4-60

Table 4-32 Total Latent Fatality Cases, 0–50 Miles (Conditional Mean Value Across All Weather Trials): ME_2 4-61

Table 4-33 Total Latent Fatality Cases, 0–100 Miles (Conditional Mean Value Across All Weather Trials): ME_2 4-61

Table 4-34 Population-Weighted Individual Latent Fatality Risk, 0–10 Miles (Conditional Mean Value Across All Weather Trials): RE_4 4-63

Table 4-35 Total Latent Fatality Cases, 0–50 Miles (Conditional Mean Value Across All Weather Trials): RE_4....4-64

Table 4-36 Total Latent Fatality Cases, 0–100 Miles (Conditional Mean Value Across All Weather Trials): RE_4....4-65

Table 4-37 Population-Weighted Individual Latent Fatality Risk, 0–10 Miles (Conditional Mean Value Across All Weather Trials): HE_2 4-68

Table 4-38 Total Latent Fatality Cases, 0–50 Miles (Conditional Mean Value Across All Weather Trials): HE_2....4-69

Table 4-39 Total Latent Fatality Cases, 0–100 Miles (Conditional Mean Value Across All Weather Trials): HE_2....4-70

Table 4-40 Conditional Mean (Across All Weather Trials) Land Area (mi^2) Exceeding Cs-137 Deposition Levels within 50 Miles of the Site 4-72

Table 4-41 Conditional Mean (Across All Weather Trials) Land Area (mi^2) Exceeding Cs-137 Deposition Levels within 100 Miles of the Site 4-73

Table 4-42 Conditional Mean Land Area (mi^2) within 100 Miles Subject to Agricultural Restrictions....4-74

Table 4-43 Conditional Mean Land Area (mi^2) within 100 Miles Subject to Population Restrictions....4-74

Table 4-44 Land Area (mi^2) Exceeding 555 kBq/m^2 (15 Ci/km^2) Cs-137, 0–50 Miles (Conditional Mean Value Across All Weather Trials): ME_2....4-79

Table 4-45 Land Area (mi^2) Exceeding 555 kBq/m^2 (15 Ci/km^2) Cs-137, 0–100 Miles (Conditional Mean Value Across All Weather Trials): ME_2....4-80

Table 4-46 Land Area (mi^2) Exceeding 555 kBq/m^2 (15 Ci/km^2) Cs-137, 0–50 Miles (Conditional Mean Value Across All Weather Trials): RE_4 4-81

Table 4-47 Land Area (mi^2) Exceeding 555 kBq/m^2 (15 Ci/km^2) Cs-137, 0–100 Miles (Conditional Mean Value Across All Weather Trials): RE_4 4-82

Table 4-48 Conditional Mean (Across All Weather Trials) Size of Population within 50 Miles Subject to Early-Phase Protective Actions 4-86
Table 4-49 Conditional Mean (Across All Weather Trials) Size of Population within 100 Miles Subject to Early-Phase Protective Actions 4-87
Table 4-50 Conditional Mean (Across All Weather Trials) Size of Population Within 50 Miles Subject to Intermediate-and Recovery-Phase Protective Actions....4-88
Table 4-51 Conditional Mean (Across All Weather Trials) Size of Population Within 100 Miles Subject to Intermediate-and Recovery-Phase Protective Actions....4-89
Table 4-52 Summary of Population Relocated during Intermediate Phase, 0–50 Miles (Persons) (Mean Value Across All Weather Trials): ME_2 4-98
Table 4-53 Summary of Population Relocated during Intermediate Phase, 0–100 Miles (Persons) (Mean Value Across All Weather Trials): ME_2....4-99
Table 4-54 Summary of Population Relocated during Intermediate Phase, 0–50 Miles (Persons) (Mean Value Across All Weather Trials): RE_4....4-100
Table 4-55 Summary of Population Relocated during Intermediate Phase, 0–100 Miles (Persons) (Mean Value Across All Weather Trials): RE_4 4-101
Table 4-56 Conditional Mean (Over All Weather Trials) Economic Costs within 50 Miles for Agricultural Restrictions (2015$)....4-105
Table 4-57 Conditional Mean (Over All Weather Trials) Economic Costs within 100 Miles for Agricultural Restrictions (2015$)....4-106
Table 4-58 Conditional Mean (Over All Weather Trials) Economic Costs within 50 Miles for Population Restrictions (2015$)....4-107
Table 4-59 Conditional Mean (Over All Weather Trials) Economic Costs within 100 Miles for Population Restrictions (2015$)....4-108
Table 4-60 Summary of Total Economic Costs, 0–50 Miles (2015$) (Conditional Mean Value Across All Weather Trials): ME_2....4-118
Table 4-61 Summary of Total Economic Costs, 0–100 Miles (2015$) (Conditional Mean Value Across All Weather Trials): ME_2....4-118
Table 4-62 Summary of Total Economic Costs, 0–50 Miles (2015$) (Conditional Mean Value Across All Weather Trials): RE_4 4-120
Table 4-63 Summary of Total Economic Costs, 0–100 Miles (2015$) (Conditional Mean Value Across All Weather Trials): RE_4 4-120
Table 5-1 Set of Offsite Public Risk Metrics Analyzed....5-1
Table 5-2 Summary of Population Dose Risk Measures 5-2
Table 5-3 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Population Dose Levels (0–50 Miles) 5-4
Table 5-4 Mean And 90% Confidence Intervals for Exceedance Frequencies of Specified Population Dose Levels (0–100 Miles) 5-4
Table 5-5 Summary of Early Fatality Risk Measures....5-6

Table 5-6 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Levels of Population-Weighted Early Fatality Risk (0–1.8 Miles) 5-8
Table 5-7 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Levels of Total Early Fatality Risk (0–50 Miles) 5-8
Table 5-8 Summary of Latent Fatality Risk Measures 5-10
Table 5-9 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Levels of Population-Weighted Latent Cancer Fatality Risk (0–10 Miles) 5-13
Table 5-10 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Numbers of Latent Cancer Fatalities (0–50 Miles) 5-13
Table 5-11 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Numbers of Latent Cancer Fatalities (0–100 Miles) 5-13
Table 5-12 Summary of Land Contamination (MACCS Type D) Risk Measures 5-15
Table 5-13 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Levels of Land Area Exceeding Cs-137 Concentration of 555 kBq/m^2 (15 Ci/km^2) (0–50 Miles) 5-18
Table 5-14 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Levels of Land Area Exceeding Cs-137 Concentration of 555 kBq/m^2 (15 Ci/km^2) (0–100 Miles) 5-18
Table 5-15 Summary of Affected Population Risk Measures 5-20
Table 5-16 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Numbers of People Affected By Intermediate-Phase Relocation (0–50 Miles) 5-22
Table 5-17 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Numbers of People Affected By Intermediate-Phase Relocation (0–100 Miles) 5-22
Table 5-18 Summary of Economic Cost Risk Measures 5-24
Table 5-19 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Levels of Total Economic Costs (0–50 Miles) 5-26
Table 5-20 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Levels of Total Economic Costs (0–100 Miles) 5-26
Table 6-1 Known Modeling Errors 6-2
Table 6-2 Potential Candidates for Future Work 6-3
Table A-1 MACCS Plume Segment Characteristics A-2
Table A-2 Plume Segment Release Fractions A-40
Table A-3 Chemical Group Release Fraction by Particle Size Distribution A-97

[Note: Due to word-processing software limitations, hyperlinks between the main report and the appendix are not functional.]

EXECUTIVE SUMMARY

The U.S. Nuclear Regulatory Commission (NRC) performed a full-scope site Level 3 probabilistic risk assessment (PRA) project (L3PRA project) for a two-unit pressurized-water reactor reference plant. The staff undertook this project in response to Commission direction in the staff requirements memorandum dated September 21, 2011 (NRC 2011a; Agencywide Documents and Management System [ADAMS] Accession No. ML112640419) resulting from SECY-11-0089, "Options for Proceeding with Future Level 3 Probabilistic Risk Assessment Activities," dated July 7, 2011 (NRC 2011b; ML11090A039).

As described in SECY-11-0089, the objectives of the L3PRA project are the following:

- Develop a Level 3 PRA, generally based on current state-of-practice methods, tools, and data,[1] that (1) reflects technical advances since the last NRC-sponsored Level 3 PRAs (i.e., NUREG-1150, "Severe Accident Risk: An Assessment for Five U.S. Nuclear Power Plants," NRC 1990), which were completed over 20 years ago, and (2) addresses scope considerations that were not previously considered (e.g., low power/shutdown, multi-unit risk, other radiological sources).

- Extract new insights to enhance regulatory decision making and to help focus limited NRC resources on issues most directly related to the agency's mission to protect public health and safety.

- Enhance PRA staff capability and expertise, and improve documentation practices to make PRA information more accessible, retrievable, and understandable.

- Demonstrate technical feasibility and evaluate the realistic cost of developing new Level 3 PRAs.

The scope of the Level 3 PRA study includes major site radiological sources, all internal and external initiating event hazards typically considered in previous internal and external event PRAs, and all modes of plant operation.[2,3] This scope exceeds that of the NUREG-1150 studies in a number of areas. In particular, as described in SECY-11-0089, the NUREG-1150 studies did not include an assessment of accidents involving other radiological sources such as spent fuel pools, dry storage casks, and other units on site. Also, the NUREG-1150 studies only addressed at-power operation (though subsequent studies for two of the NUREG-1150 plants involved a limited analysis of low-power and shutdown modes of operation) and only partially addressed external hazards. The Level 3 PRA study also incorporates advances made in PRA technology since the completion of the NUREG-1150 studies, as well as more recent changes in nuclear power plant operational performance and safety. This report documents the Level 3 consequence analysis for the reactor low-power and shutdown (LPSD) probabilistic risk assessment (PRA) model, focused on internal events during refueling outages.

---

[1] "State-of-practice" methods, tools, and data refer to those that are routinely used by the NRC and licensees or have acceptance in the PRA technical community.

[2] Deliberate malevolent acts (e.g., terrorism and sabotage) are specifically excluded from the scope of the study.

[3] Including all reactor cores, spent fuel pools, and dry storage casks on site, but excluding fresh nuclear fuel, radiological waste, and minor radiological sources (e.g., calibration devices).

A Technical Analysis Approach Plan (TAAP) was developed to provide guidance for developing the Level 3 PRA study (NRC, 2013). The TAAP helps ensure consistency with current best practices and enhances consistency in the development of the PRA models by the various analysts. The TAAP also provides traceability of how the Level 3 PRA models were constructed and is used to support development of review criteria for assessing the technical acceptability of the PRA models.

The report was developed by updating the report for the reactor at-power internal events and floods consequence analysis (NRC 2022a) to address changes associated with the radiological source terms documented in NRC (2025). Because many aspects of the technical discussions are identical to those in the reactor at-power analysis, some sections did not need to be updated. These sections are identified in this report and it is recommended that the reader consult NRC (2022a) for those sections. In other sections, there are some differences between the reactor at-power analysis, and these differences are sufficient enough that the text was retained with adaptations to reflect the differences, and the adaptations were noted accordingly. Other sections were completely updated.

Licensee information used in performing the L3PRA project was voluntarily provided based on a licensed, operating nuclear power plant. The information provided reflects the plant as it was designed and operated as of 2012 and does not reflect the plant as it is currently designed, licensed, operated, or maintained. In addition, the information provided for the reference plant was changed based on additional information, assumptions, practices, methods, and conventions used by the NRC in the development of plant-specific PRA models used in its regulatory decisionmaking. **As such, this report will not be the sole basis for any regulatory decisions specific to the reference plant.**

The MACCS code was selected for the offsite consequence analysis component of the L3PRA project as it is one of the current standard code systems used for probabilistic consequence analysis with a long pedigree, a record of continuous development, and an extensive history of application to a wide variety of assessments. It also has the capability to model a wide variety of features, events, and processes (i.e., atmospheric dispersion and deposition, exposure and dose assessment from multiple pathways, protective actions, acute and stochastic health effects, and economic impacts) in a fully coupled fashion, while allowing for probabilistic treatment of potential weather conditions at the time of the release. No other available code system was judged to have the combination of characteristics needed to support this assessment.

Risk metrics reported for the L3PRA project were chosen to be consistent with current regulatory applications, allow comparison with previous studies, and provide additional information to assist in the interpretation of the reported results. The specific offsite public risk metrics provided in this report include the following:

- population-weighted risk to an individual within 1.6 kilometers (km) (1 mile [mi]) of the site boundary of an early fatality (early fatality risk per calendar year [yr])

- population-weighted risk to an individual within 16 km (10 mi) of the site of a latent cancer fatality (cancer fatality risk/yr)

- total early fatality risk across the population within 80 and 161 km (50 and 100 mi)[4] of the site (fatalities/yr)

- total latent cancer fatality risk across the population within 80 and 161 km (50 and 100 mi) of the site (fatalities/yr)

- collective total effective dose risk integrated across the population within 80 and 161 km (50 and 100 mi) of the site (person-rem/yr)

- economic cost risk integrated across the region within 80 and 161 km (50 and 100 mi) of the site (2015$/yr)

- intermediate phase population relocation risk integrated across the population within 80 and 161 km (50 and 100 mi) of the site (person relocated/yr)

- impacted land area (area exceeding 555 kilobecquerels/m^2 (15 curies/km^2) deposition of cesium-137) integrated across the region within 80 and 161 km (50 and 100 mi) of the site (mi^2/yr)

In general, reviews of a wide range of results for this study suggest that for most accident sequences, warning times on the order of a few hours are sufficient to minimize the population subject to moderate or high doses in the early phase. Only three LPSD source terms are modeled with warning times less than 24 hours, with a combined frequency of 5.3×10^{-7}/yr. All of these are source terms in which the initiating event occurs relatively shortly (12–55 hours) after reactor shutdown and containment is open or bypassed. Effectively, no populations were projected to receive the high doses needed to induce early health effects. The examination of early fatality risk (or comparably, the risk of high exposures) suggests that the extremely low likelihood of high doses to the offsite public results from the following factors:

- Very low frequency of events that would generate relatively large and fast releases

- relatively low frequency of adverse meteorological conditions (primarily stable, low-windspeed conditions)

- very sparse close-in population, which limits the likelihood of the wind blowing in the direction of a populated sector very close to the site

- low likelihood of delayed and/or slow evacuation of the populations toward which the winds are blowing

The patterns observed in the low but non-zero early fatality risk results provide a level of confidence in the results by allowing a more complete characterization of factors that result in extremely low risk of early health effects as well as the low risk of elevated doses that are more likely to lead to cancer.

---

[4] Early fatalities, if projected to occur at all, are limited to areas well within 80 km (50 mi) of the site. There is, therefore, no numerical difference between the total number of early fatality cases from 0–80 km (0–50 mi) and from 0–161 km (0–100 mi). Because of this, values for early fatalities from 0–161 km (0–100 mi) are not reported separately.

These particular results are site specific. Sites for which these factors are less applicable (i.e., higher close-in population densities, coupled with higher likelihood of slow or delayed evacuations) may experience a higher risk of elevated exposures. However, it may be noted that even with the significantly delayed evacuation modeled in the degraded evacuation scenarios for seismic events during the reactor at-power scenarios, the risk of high exposures (and particularly of fatal early health effects) is still extremely low, which suggests that there are multiple factors beyond evacuation speed that serve to lower the risk of early health effects.

As a result of the above factors, the bulk of the radiological exposure arises from reoccupation of land after decontamination and natural decay and weathering reduce exposures to levels below the habitability criteria assumed in the analysis. These levels are in the low to very low dose range. From an epidemiological standpoint, it is unlikely that the number of latent cancer fatalities attributable to radiation exposure from releases from a severe accident would be statistically observable above the expected number of cancer fatalities in the exposed population from all other causes (i.e., the excess cancer fatalities predicted are too few to allow the detection of a statistically significant difference in the cancer fatalities expected from other causes among the same population).

Additional insights based on a review of the major contributors to risk are as follows:

- There is generally about an order of magnitude in epistemic uncertainty arising from imperfect knowledge about the values of input parameters in the Level 1 and Level 2 PRA logic models. In other words, the points on the 95th and 5th percentile CCDF curves at specified consequence levels generally differ by about a factor of 10 (though this range begins to narrow at the very large consequence levels). Although early health effects are subject to a larger (about a factor of 50) range of uncertainty stemming from the Level 1 and Level 2 PRA logic models, it should be noted that the absolute values for the frequency of non-zero early health effects are nonetheless extremely low (less than 10-7 per reactor-year even at the upper end).

- Offsite public risk metrics, other than those that relate to early health effects, are generally dominated by the same radiological release categories, though the specific order may vary: (1) a release category in which the containment fails due to overpressure by steam sometime in between the start of the accident and the start of core damage (SD-CF-Before-CD), (2) a release category in which the release to the environment occurs via a containment penetration that fails to be isolated by manual action or via a pre-existing leakage path (not including open containment hatch or personnel airlock) (SD-CIF); and (3) the three release categories that involve an open containment hatch and/or personnel airlock, with operator failure to reclose them, and for which the release is considered to reach the environment directly via these large openings (SD-COPEN-HEADOFF, SD-COPEN-RCSINTACT, SD-COPEN-RCSVENT). A modest contribution (4–10 percent) also comes from a release category in which the containment fails hours after vessel breach due to a global deflagration or detonation (SD-ICF-BURN), except for land contamination risk, for which SD-ICF-BURN only contributes on the order of 1 percent.

- Offsite public risk metrics that relate to early health effects (which are very low) arise only from the SD-COPEN-RCSVENT and SD-COPEN-HEADOFF release categories, with virtually the entire contribution (99.9 percent) coming from SD-COPEN-RCSVENT. For SD-COPEN-RCSVENT, prior to any breach of the reactor vessel lower head by core

debris, the RCS is vented or has a persistent leak not including normally cycling relief valves (e.g., pipe break or manual bleed), such that retention of aerosols inside the RCS may be intermediate in magnitude.

- The accident termination time of 7 days after event initiation is selected for use in the Level 3 analysis. As discussed in Section 2.6.4 of NRC (2022b), this is a longer accident termination time in comparison to past Level 2 PRA studies. This modeling assumption most significantly impacts the ICF-BURN release category, but also results in a noticeable (>10 percent) reduction in the conditional consequences for the COPEN-RCSVENT and COPEN-RCSINTACT release categories. The overall effect of imposing a shorter accident termination time (i.e., 36 hours after entry into the severe accident management guidelines) is to reduce most risk metrics by 12–16 percent, though the reduction is in the general area of 25 percent specifically for population-weighted individual latent cancer fatality risk and risk of population affected by intermediate-phase relocation and is minimal for early fatality risk and land contamination risk. It should be noted, however, that imposing a shorter accident termination time could result in significantly underestimating the release.

- Offsite public risk metrics other than those that relate to early health effects generally have a similar set of significant risk contributors for the reactor at-shutdown, in terms of composite FV importance. In terms of initiating events, LOOP is by far the largest contributor (generally, around 80 percent). Other significant initiating event contributors (generally, in the 3–5 percent range) include (1) loss of NSCW, (2) loss of RHR, (3) loss of a 4,160 V AC bus, and (4) an overdraining event with the reactor in mid-loop operation.

- Also, just two POSs, refueling operation and when the pressurizer is water solid for hydrogen degassing prior to refueling, generally contribute around 80 percent to all offsite public risk metrics other than those that relate to early health effects.

- Aside from the boundary condition basic events (i.e., related to plant operating type and state) and initiating events, most of the highest contributing events involve various human errors (e.g., failures to restore electric power, failure to establish low-pressure gravity feed given LOOP, failure to isolate small containment penetrations [with high dependency on a previous operator failure], or failure of emergency closure of the equipment hatch with no AC power available). Other high contributing events include failures leading to a station blackout (e.g., failures of diesel generators, RAT input breakers, or load sequencers).

- Offsite public risk metrics that relate to early health effects also have a similar set of significant risk contributors for the reactor at-shutdown, in terms of composite FV importance. LOOP is the initiating event contributing by far the most (approximately 90 percent), while loss of inventory initiating events collectively contribute an additional 8 percent. Also, approximately 93 percent of early fatality risk occurs in just two POSs, draining the RCS to mid-loop prior to refueling (56 percent) or after refueling (37 percent).

Aside from the boundary condition basic events and initiating events, the top two basic event contributors to both early fatality risk measures are (1) operator failure to establish low pressure gravity feed given a LOOP (approximately 83 percent) and (2) operator failure to close the

equipment hatch with lowered RCS inventory and no AC power (approximately 81 percent). Other significant contributors to early fatality risk include equipment failures or operator errors that lead to a station blackout. Included in this set of basic events are common-cause failures of the RAT input breakers (contributing 33 percent) and the load sequencers (contributing 20 percent), as well as random failures of these components and the diesel generators, and operator failure to recover offsite power.

A sensitivity analysis was performed using a model that estimates cancer risk based only on annual individual doses greater than 0.05 sieverts (5 rem), or lifetime individual doses greater than 0.1 sievert (10 rem). The results of this sensitivity analysis shows that projected cancer risks are greatly reduced when compared to those based on the linear, no threshold dose-response model. This lends further support to the observation that most accidents initiated during LPSD operations resulting in core damage do not result in high individual doses at the reference site because of effective early-phase protective actions. Only the relatively infrequent events that exhibit low warning times coupled with large releases are likely to result in elevated doses at the reference site.

ACKNOWLEDGMENTS

A. Nosek, U.S. NRC	Initial MACCS model development efforts
D. Hudson, U.S. NRC (former)	Initial risk integration analyses and documentation
S. Dennis, U.S. NRC	Initial risk integration efforts and documentation
A. Kuritzky, U.S. NRC	Final risk integration efforts and documentation
S. Thompson, U.S. NRC (former)	Initial MACCS model development efforts
R. Sullivan, U.S. NRC (retired)	Emergency response modeling
T. Smith, U.S. NRC	Emergency response modeling
M. Mazaika, U.S. NRC	Meteorological data review
N. Bixler, SNL (retired)	MACCS modeling support
J. Jones, SNL (retired)	Emergency response modeling
F. Walton, SNL	Initial MACCS model development efforts
K. McFadden, Sigma Software LLC	MACCS modeling support and documentation
L. Eubanks, Architrave Software Inc.	MACCS modeling support and documentation
R. Haaker, AQ Safety, Inc.	MACCS modeling support and documentation
B. Wolshon, Louisiana State University	Evacuation modeling

ABBREVIATIONS AND ACRONYMS

AC:	Alternating Current
ADAPT:	Atmospheric Data Assimilation and Parameterization Techniques
AFW:	Auxiliary Feed Water
ATD:	Atmospheric Transport and Dispersion
BLS:	Bureau of Labor and Statistics
CCDF:	Complementary Cumulative Distribution Functions
CEC:	Commission of European Communities
CETC:	Core-Exit Thermocouple
CPI:	Consumer Price Index
CSFST:	Critical Safety Function Status Tree
DOE:	United States Department of Energy
EAB:	Exclusion Area Boundary
EAL:	Emergency Action Level
ECCS:	Emergency Core Cooling System
ED:	Emergency Director
EDG:	Emergency Diesel Generator
EPZ:	Emergency Planning Zone
ER:	Environmental Report
ESP:	Early Site Permit
ETE:	Evacuation Time Estimate
FEIS:	Final Environmental Impact Statement
GE:	General Emergency
ISLOCA:	Interfacing System Loss-of-Coolant Accident
LHS:	Latin Hypercube Sampling
LNT:	Linear no-threshold (as a dose-response model for cancer risk)
LOCA:	Loss-of-Coolant Accident
LODI:	Lagrangian Operational Dispersion Integrator
LOOP:	Loss-of-Offsite Power
LPSD:	Low-Power and Shutdown
NEPA:	National Environmental Policy Act
NSCW:	Nuclear Service Cooling Water
NWS:	National Weather Service
PAG:	Protective Action Guideline
PAR:	Protective Action Recommendation
PORV:	Power-Operated Relief Valve
PWROG:	Pressurized Water Reactor Owners Group
RCP:	Reactor Coolant Pump
RCS:	Reactor Coolant System
RVLIS:	Reactor Vessel Level Instrumentation System
SAE:	Site Area Emergency
SAPHIRE:	Systems Analysis Programs for Hands-on Integrated Reliability Evaluations
SBO:	Station Blackout
SG:	Steam Generator
SGTR:	Steam Generator Tube Rupture
SNL:	Sandia National Laboratories
SOARCA:	State of the Art Reactor Consequence Analyses
TAF:	Top of Active Fuel
WMA:	Wildlife Management Area

1 INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) performed a full-scope site Level 3 probabilistic risk assessment (PRA) project (L3PRA project) for a two-unit pressurized-water reactor reference plant. The staff undertook this project in response to Commission direction in the staff requirements memorandum dated September 21, 2011 (Agencywide Documents and Management System [ADAMS] Accession No. ML112640419) resulting from SECY-11-0089, "Options for Proceeding with Future Level 3 Probabilistic Risk Assessment Activities," dated July 7, 2011 (ML11090A039).

As described in SECY-11-0089, this project has the following objectives:

- Develop a Level 3 PRA, generally based on current state-of-practice methods, tools, and data,[1] that (1) reflects technical advances since the last NRC-sponsored Level 3 PRAs (i.e., NUREG-1150, "Severe Accident Risk: An Assessment for Five U.S. Nuclear Power Plants," [NRC 1990]), which were completed over 20 years ago, and (2) addresses scope considerations that were not previously considered (e.g., low power/shutdown, multi-unit risk, other radiological sources).

- Extract new insights to enhance regulatory decision making and to help focus limited NRC resources on issues most directly related to the agency's mission to protect public health and safety.

- Enhance PRA staff capability and expertise and improve documentation practices to make PRA information more accessible, retrievable, and understandable.

- Demonstrate technical feasibility and evaluate the realistic cost of developing new Level 3 PRAs.

This report documents a description and results for the reactor low-power and shutdown (LPSD) Level 3 PRA model, focused on internal events during refueling outages, that supports the L3PRA project.

Licensee information used in performing the L3PRA project was voluntarily provided based on a licensed, operating nuclear power plant. The information provided reflects the plant as it was designed and operated as of 2012 and does not reflect the plant as it is currently designed, licensed, operated, or maintained. (For example, the L3PRA does not reflect the current reactor coolant pump shutdown seal design or the potential impact of FLEX strategies.[2]) In addition, the information provided for the reference plant was changed based on additional information, assumptions, practices, methods, and conventions used by the NRC in the development of

---

[1] "State-of-practice" methods, tools, and data refer to those that are routinely used by the NRC and industry or have acceptance in the PRA technical community. While the L3PRA project is intended to be a state-of-practice study, note that there are several technical areas within the project scope that necessitated advancements in the state-of-practice (e.g., modeling of multi-unit site risk, modeling of spent fuel in pools or casks, and of human reliability analysis for other than internal events and internal fires).

[2] FLEX refers to the U.S. nuclear power industry's proposed safety strategy, called Diverse and Flexible Coping Strategies. FLEX is intended to maintain long-term core and spent fuel cooling and containment integrity with installed plant equipment that is protected from natural hazards, as well as backup portable onsite equipment. If necessary, similar equipment can be brought from off site.

plant-specific PRA models. **As such, the L3PRA project reports will not be the sole basis for any regulatory decisions specific to the reference plant**.

Since the L3PRA project involves multiple PRA models, each of these models should be considered a “living PRA” until the entire project is complete. It is anticipated that the models and results of the L3PRA project are likely to evolve over time, as other parts of the project are developed, or as other technical issues are identified. As such, the final models and results of the project (which will be documented in a summary report to be published after all technical work for the L3PRA project has been completed) may differ in some ways from the models and results provided in the current report.

The series of reports for the L3PRA project are organized as follows:

Volume 1: Final summary report

Volume 2: Background, site and plant description, and technical approach

Volume 3: Reactor, at-power, internal event and flood PRA (overview report)

- Volume 3a: Level 1 PRA for internal events
- Volume 3b: Level 1 PRA for internal floods
- Volume 3c: Level 2 PRA for internal events and floods
- Volume 3d: Level 3 PRA for internal events and floods

Volume 4: Reactor, at-power, internal fire and external event PRA (overview report)

- Volume 4a: Level 1 PRA for internal fires
- Volume 4b: Level 1 PRA for seismic events
- Volume 4c: Level 1 PRA for high wind events and other hazards evaluation
- Volume 4d: Level 2 PRA for internal fires and seismic and wind-related events
- Volume 4e: Level 3 PRA for internal fires and seismic and wind-related events

Volume 5: Reactor, low-power and shutdown, internal event PRA (overview report)

- Volume 5a: Level 1 PRA for internal events
- Volume 5b: Level 2 PRA for internal events
- Volume 5c: Level 3 PRA for internal events

Volume 6: Spent fuel pool all hazards PRA (no overview report)

- Volume 6a: Level 1 and Level 2 PRA
- Volume 6b: Level 3 PRA

Volume 7: Dry cask storage, all hazards, Level 1, Level 2, and Level 3 PRA

Volume 8: Integrated site risk, all hazards, Level 1, Level 2, and Level 3 PRA

The details of the reactor Level 3 PRA for LPSD operations are documented in this report. A discussion of the documentation approach for this report is provided in Section 1.1. Section 1.2 describes how the various sections of this report relate to the technical elements from the draft

Level 3 PRA standard. Section 1.3 discusses the identification and treatment of uncertainties associated with the Level 3 PRA.

The scope of the Level 3 PRA study includes major site radiological sources, all internal and external initiating event hazards typically considered in previous internal and external event PRAs, and all modes of plant operation.[3,4] This scope exceeds that of the NUREG-1150 studies in several areas. As described in SECY-11-0089, the NUREG-1150 studies did not include an assessment of accidents involving other radiological sources such as spent fuel pools, dry storage casks, and other units on site. Also, the NUREG-1150 studies only addressed at-power operation (though subsequent studies for two of the NUREG-1150 plants involved a limited analysis of low power and shutdown modes of operation) and only partially addressed external hazards.

CAUTION: While the L3PRA project is intended to be a state-of-practice study, due to limitations in time, resources, and plant information, some technical aspects of the study were subjected to simplifications or were not fully addressed. As such, inclusion of approaches in the L3PRA project documentation should not be viewed as an endorsement of these approaches for regulatory purposes.

1.1 Documentation

This report was developed by updating the report for the reactor at-power internal events/internal floods consequence analysis (NRC 2022a) to address changes associated with the modeling of events initiated during LPSD operations. The document architecture for this report is therefore parallel to the document architecture used for the internal events/internal floods consequence analysis. Because many aspects of the technical discussions are identical to those in the reactor at-power analysis, some sections did not need to be updated. These sections are identified in this report, and it is recommended that the reader consult NRC (2022a) for those sections. In other sections, there are some differences between the reactor at-power analysis, and these differences are sufficient enough that the text was retained with adaptations to reflect the differences, and the adaptations were noted accordingly. Other sections were completely updated.

The technical basis for the input data is discussed in Section 3. Each subsection of Section 3 comprises a section on assumptions (either adapted from those identified in the TAAP or identified during the development of the technical inputs as a key assumption), a technical discussion where the sources and a summary of the technical basis for the input parameters are provided, a summary table identifying the value of the MACCS parameters, and a section identifying key sources of uncertainty. The assumptions and limitations identified in the internal events/internal floods analysis are reproduced for convenience and are supplemented with any additional assumptions needed to conduct the LPSD analysis. Many technical bases for input parameters used for the LPSD analysis are identical to the technical bases developed for the reactor at-power analysis. In such cases, this document simply indicates that the section has been included to maintain section numbering consistent with the reactor at-power analysis. The reader may therefore consult the analogous section of NRC (2022a) for a complete description

[3] Deliberate malevolent acts (e.g., terrorism and sabotage) are specifically excluded from the scope of the study.

[4] Including all reactor cores, spent fuel pools, and dry storage casks on site, but excluding fresh nuclear fuel, radiological waste, and minor radiological sources (e.g., calibration devices).

of the technical basis for that aspect of the consequence modeling. The summary table identifying the value of the MACCS parameters is adapted from the analogous table in the reactor at-power analysis. For convenience, the section identifying key sources of uncertainty and candidate sensitivity analysis is retained from the reactor at-power analysis and is supplemented (if necessary) with any additional sources of uncertainty and candidate sensitivity analyses associated with the LPSD analysis.

Section 4 provides a presentation of the results in tabular form for each release category modeled by MACCS, followed by a discussion of the results. Section 5 discusses risk integration. Section 6 contains a list of known errors in the current model, as well as a list of candidates for future work.

1.2 Relationship to ASME/ANS Level 3 PRA Standard

While the Level 3 PRA project was underway, an ASME/ANS standard for Level 3 PRA was under development and draft versions were available (ANS/ASME 2010, ASME/ANS 2015). The Level 3 PRA standard has since been issued for trial use and pilot application (ASME/ANS 2017). This report has been developed with the technical elements and high-level requirements defined by the draft Level 3 PRA standards in mind but does not exactly follow the specific hierarchy defined by the supporting requirements in that document. In general, the subsections of Section 3 correspond to the technical elements identified in Section 4 of the draft standard related to model inputs. Table 1-1 shows the relationship of the technical elements from the draft Level 3 PRA standard to sections of this report. Section 4 of this report corresponds to the Conditional Consequence Quantification and Reporting technical element, as well as the Risk Integration technical element in Section 5 of the draft Level 3 PRA standard, and Section 5 of this report also corresponds to the Risk Integration technical element. For ease of discussion, some technical elements have been treated in a combined fashion; that is, because the costs captured in the economic factors technical element are all related to specific protective actions, the discussion of the protective actions and their costs are combined. In addition, the order in which the technical elements are addressed is different from that followed in the standard. The order in this document is based on the conceptual flow of a consequence calculation from release, environmental transport, exposure assessment, dose assessment, and health effects characterization. Since protective actions are generally intended to limit exposure to released radioactivity, they are therefore treated after the atmospheric transport assessment, but before the dose assessment.

The 2015 version of the draft standard was used to perform both a self-assessment and an external peer review conducted in September of 2015 by a Pressurized Water Reactor Owner's Group (PWROG)-led team on a preliminary version of the reactor, at-power, internal events/internal floods analysis (NRC 2022a). Although an external peer review, as discussed in Section 1.2 of NRC (2022a) for the reactor at-power analysis, has not been performed for the LPSD analysis, the current analysis and report incorporate feedback from the peer review of the reactor at-power analysis.

Table 1-1 Relationship of Technical Elements from the Draft Level 3 PRA Standard to this Report

Technical Element	Report Subsection
Radionuclide Release Characterization for Level 3	3.1
Protective Action Parameters and Other Site Data	3.4
Meteorological Data	3.2
Atmospheric Transport and Dispersion	3.3
Dosimetry	3.5
Health Effects	3.6
Economic Factors	3.4
Conditional Consequence Quantification and Reporting	4
Risk Estimation	4 and 5

1.3 Identification and Treatment of Uncertainties

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis. However, the lists of uncertainties and candidate sensitivity analyses at the end of each subsection of Section 3 of this document, as well as the list of assumptions at the beginning of each subsection of Section 3 of this document, are reproduced from NRC (2022a). These lists have been supplemented with additional assumptions, uncertainties, or candidate sensitivity analyses related to analysis of events initiated during LPSD operations.

2 BACKGROUND AND GENERAL INFORMATION

2.1 The MACCS Probabilistic Offsite Consequence Analysis Code

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

2.2 General Site Information

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3 INPUT DATA

3.1 Radionuclide Release Characterization for Level 3 (RE)

3.1.1 Assumptions and Known Limitations

The following assumptions and limitations are reproduced from NRC (2022a):

- The default list of radionuclides to be explicitly considered adequately captures the potential doses associated with radioactive releases to the environment.

- Chemical class assignments defined in MELCOR adequately capture the atmospheric transport and deposition properties of the released radionuclides.

- Downwash and mixing within the turbulent wake of the structures, along with a highly uncertain release location for non-stack releases, is not modeled explicitly. Instead, the physical release height elevation from the MELCOR model (corrected as necessary to elevation above grade) is used as the initial release height for the plume. This is not expected to be a significant source of uncertainty for offsite locations, which are modeled as greater than 0.75 miles from the point of release.

- Very small, prolonged releases can be adequately modeled without a high degree of temporal resolution (i.e., plume segments of up to 24 hours) without significantly affecting the overall analysis results.

The following supplemental assumptions are included as part of the LPSD analysis:

- The analysis uses radionuclide-specific release characteristics based on the results of the Level 2 accident progression analyses documented in NRC (2025), including the quantity and form; the timing and duration; and the energy and the height of each release.

- Reactor core radionuclide inventories reflect the inventory at shutdown following a coastdown and are determined using the ORIGIN2/SCALE computer code package. The sequence-specific delay time between the shutdown and accident initiation is added to the MELCOR timelines, which are relative to accident initiation rather than shutdown, to properly account for decay and ingrowth of radionuclides following shutdown.

- The MelMACCS feature which automatically scales the activity of the radionuclides considered in the MACCS analysis based on the mass of the activity defined in the MELCOR analysis is assumed to adequately reflect the post-refueling core inventory. This resulted in scaling the core inventory by a factor of 54 percent of the pre-refueling mass to account for the removal of spent fuel assemblies from the core following refueling (i.e., the replacement of 89 of the 193 fuel assemblies with fresh fuel [1-89/193 = 0.54]).

- It should be noted that release category frequencies for LPSD events are given in terms of calendar-years, whereas release category frequencies for reactor at-power events are typically given in terms of reactor-years. The number of reactor-years accumulated by a single reactor during a calendar-year is slightly less than 1 reactor-year because, on

average, the reactor will be shut down for at least part of the year (i.e., the plant availability factor will be less than 1.0). To convert the release frequency of the ***reactor at-power*** from per reactor-year to per calendar-year, multiply the frequency by the plant availability factor of 0.93. However, it should be noted that the resulting reactor, at-power, calendar-year release frequency does not include the contribution from reactor shutdown operations during the calendar year.

3.1.2 Technical Discussion

A source term in MACCS is a discrete set of parameters with information on the time-dependent radionuclide release rate, plume buoyancy, and aerosol characteristics. Because emergency action levels are often based on accident progression characteristics that are characterized as part of source term development, a source term is typically associated with an estimate of the timing of any emergency declarations associated with that release. These values are computed in the Level 2 portion of the analysis using the MELCOR (Humphries et al. 2015) phenomenological model of accident progression.

Once a source term is generated, the process for importing the results of the phenomenological accident progression modeling into a form suitable for modeling of offsite consequences involves the following five steps (described in the subsections that follow):

1. Identification of radionuclides and development of initial radionuclide inventory (Section 3.1.2.3)

2. Assignment of radionuclides to chemical classes (Section 3.1.2.4)

3. Determination of the aerosol characteristics (i.e., particle-size distribution) for each chemical class (Section 3.1.2.5)

4. Characterizing the characteristics of the release path that can affect initial dispersion of the plume (Section 3.1.2.6)

5. Discretization of the time-dependent radionuclide releases into plume segments (Section 3.1.2.7)

Before discussing the above steps, the use of the MelMACCS code is briefly described below, followed by a discussion of the transition of the Level 2 PRA to the Level 3 PRA (Section 3.1.2.1) and a discussion of source term characteristics important for the Level 3 analysis (Section 3.1.2.2).

The MACCS preprocessor code MelMACCS was used to assist in the process of converting the results of MELCOR computations into a format suitable for use in MACCS.. The MelMACCS code relies on three sources of data: a properly formatted .ptf file generated by MELCOR; a MelMACCS initialization (.inf) file containing default parameters, such as information on core inventories and chemical class assignments, generally based on detailed ORIGEN/SCALE calculations; and user-supplied inputs. Parameters defined in the MelMACCS initialization file needed for the development of MACCS parameters are discussed in this section. MelMACCS may also be run in batch mode, with user-supplied inputs provided in a “.mel” file. This option was used in the Level 3 PRA MACCS models used in the documented analysis, as it provides

the benefit of documenting the user-supplied inputs and minimizes the possibility of user errors in entering input values.

3.1.2.1 Transition from Level 2 PRA to Level 3 PRA

A detailed discussion of the process for selection/identification of release categories for the LPSD analysis can be found in Section 2.5 of NRC (2025). The resulting 12 release categories are identified in Table 2-22 of NRC (2025) and are summarized here in Table 3-1.

Table 3-1 Summary of Release Categories from Level 2 Analysis

Name	Description
COPEN-HEADOFF	The containment hatch and/or personnel airlock are open at the time when the accident begins, and operators fail to reclose them. The release is considered to reach the environment directly via these large openings. Furthermore, the plant is in an operating state at the time of the accident where the reactor vessel head has been removed, so in-vessel release from the core benefits from little to no retention inside the RCS.
COPEN-RCSVENT	The containment hatch and/or personnel airlock are open at the time when the accident begins, and operators fail to reclose them. The release is considered to reach the environment directly via these large openings. Prior to any breach of the reactor vessel lower head by core debris, the reactor coolant system is vented or has a persistent leak not including normally cycling relief valves (e.g., pipe break or manual bleed), such that retention of aerosols inside the RCS may be intermediate in magnitude.
COPEN-RCSINTACT	The containment hatch and/or personnel airlock are open at the time when the accident begins, and operators fail to reclose them. The release is considered to reach the environment directly via these large openings. Prior to any breach of the reactor vessel lower head by core debris, the reactor coolant system is intact, such that releases from the RCS to the containment can occur only by normal cycling of the pressurizer and/or RHR relief valves; therefore, significant retention of aerosols inside the RCS is possible.
ISLOCA (a.k.a., LOI-OC)	The accident consists of a pipe break to a location outside of the containment (i.e., into the auxiliary building). Releases reach the auxiliary building via this break from the reactor coolant system, and from there to the environment. The release category does not distinguish between cases where the auxiliary building remains intact and leaks relatively slowly to the environment, from cases where the auxiliary building fails due to steam overpressure or energetic event. Also, whether or not the release may be scrubbed by a water pool overlying the break is left unspecified.
ISGTR	One or more steam generator tubes fail after the start of core damage due to temperature-induced creep rupture. The release to the environment occurs via the break thus created in the damaged steam generator, and from there to the environment via atmospheric relief valves or secondary-side leaks. The release category does not distinguish between cases where relief valves cycle normally in response to steam line pressure versus cases where the valves have failed in the open position or been forced open by previous operator action.
CF-BEFORE-CD	The containment fails due to overpressure by steam sometime in between the start of the accident and the start of core damage. This release may or may not benefit from any aerosol scrubbing.
ECF	The containment fails sometime in between the start of core damage and the time frame at and around vessel breach due to an energetic event. This release may or may not benefit from any aerosol scrubbing.

Table 3-1 Summary of Release Categories from Level 2 Analysis (cont.)

Name	Description
CIF	Release from the containment to the environment occurs via a containment penetration that fails to be isolated by the containment isolation system or by manual action, or a pre-existing leakage path (not including open containment hatch or personnel airlock). This release may or may not benefit from any aerosol scrubbing. Also, depending on the type and location of the isolation failure, the release may benefit from some retention inside the auxiliary building.
ICF-BURN	The containment fails some hours after vessel breach due to a global deflagration or detonation. This release may or may not benefit from any aerosol scrubbing.
LCF	The containment fails at some time between tens of hours after the time of vessel breach, up to as late as 7 days after the start of the accident, due to long-term quasi-static overpressure. Releases to the environment are not mitigated significantly by sprays or water pools.
BMT	The containment eventually fails due to basemat ablation due to sustained core-concrete interaction, at some point within 7 days of the start of the accident. Only the airborne component of release to the environment (which stems from normal design-basis containment leakage while the containment is pressurized) is modeled here.
NOCF	Containment is not open, unisolated, bypassed, or failed, and radiological release to the environment occurs via design-basis containment leakage only. This release may or may not benefit from any aerosol scrubbing.

Source: adapted from Table 2-22 of NRC (2025)

For the reactor LPSD analysis, the Level 2 team identified 13 representative sequences with 22 permutations, for a total of 35 modeling cases. The set of representative sequences and permutations is shown in Table 3-2. Each of these cases was modeled using the MELCOR code. MELCOR summarizes its phenomenological modeling result in a ".ptf" file containing the release characteristics or *source terms*. The MELCOR phenomenological modeling was performed as documented in NRC (2025).

Table 3-2 Description of Representative Sequences and Permutations

Case #	Base Scenario	Permutations
SD01	Transient in plant operating state (POS) 6 with Forced Feed	1. Suppression of deflagration events 2. Energetic containment failure at the time of vessel breach 3. Energetic containment failure 4 hours after vessel breach 4. EDMG-based containment spray 2 hours after vessel breach with energetic containment failure 4 hours after vessel breach 5. Containment overpressure failure with alternate containment failure location 6. Containment spray with energetic containment failure 35 hours after vessel breach, alternate containment failure location 7. Containment spray with energetic containment failure 35 hours after vessel breach, failure through the tendon gallery 8. Containment spray (with low spray inventory) with energetic containment failure 35 hours after vessel breach, failure through the tendon gallery 9. Containment spray (with high spray inventory) with energetic containment failure 35 hours after vessel breach, failure through the tendon gallery 10. Containment isolation failure through mini-purge line with credit for filters 11. Containment isolation failure through mini-purge line with no credit for filters 12. Containment isolation failure due to undetected liner tear at low containment elevation 13. Containment isolation failure due to undetected liner tear at high containment elevation
SD02	Transient in POS 10 with Gravity Feed	None
SD03	SBO in POS 8E with Gravity Feed and Unisolated Containment	1. EDMG-based containment spray 2 hours after vessel breach
SD04	SBO in POS 8L with Gravity Feed	None
SD05	SBO in POS 8E with Equipment Hatch Open	None

Table 3-2 Description of Representative Sequences and Permutations (cont.)

Case #	Base Scenario	Permutations
SD06	Transient in POS 11 with Forced Feed and Equipment Hatch Open	1. Stuck-open RHR relief valve with EDMG-based containment spray 2 hours after vessel breach
SD07	SBO in POS 5A with Equipment Hatch Open	1. Open containment by open personnel airlock 2. EDMG-based containment spray 2 hours after vessel breach
SD08	Transient in POS 3 with Containment Sprays	1. Suppression of creep-induced failure of RCS components 2. Two RCPs operate until consequential trip
SD09	SBO in POS 8E following Gravity Feed	None
SD10	Loss of Inventory in POS 8E with Forced Feed	1. Suppression of deflagrations
SD11	Loss of Inventory in POS 5A with Forced Feed	1. Interfacing-systems LOCA
SD12	Loss of Inventory in POS 10 with Forced Feed	1. Fan coolers failed by the first large deflagration in containment
SD13	SBO in POS 5B with Equipment Hatch Open	None

Source: adapted from Table 2-3 of NRC (2025)

In a preliminary version of the reactor, at-power, internal events and internal floods analysis, the results of the MELCOR modeling of the source terms were reviewed by NRC and SNL experts in accident progression and emergency response using information from the MELCOR phenomenological model. The emergency action level (EAL) scheme from the site emergency plan was used to identify when EALs would be reached, and therefore, when the declaration of an accident class, such as a site area emergency (SAE) or a general emergency (GE), would be expected for that MELCOR source term. The results of this review suggested that the approach used to develop proposed EAL timings based on plant conditions recommended by the Level 2 PRA team was reasonable. The recommended EAL timings provided by the Level 2 PRA team are therefore used in this analysis. The recommendations are summarized in Table 3-3 below, reproduced from Table 2-23 of NRC (2025). A comparison of the estimated GE declaration time to release timings is shown in Table 3-4, reproduced from Table 2-24 of NRC (2025).

Table 3-3 Preliminary Reactor-At-Shutdown EAL Classifications

Rep. Seq. No.	Alert Decl.[1] (hr)	SAE Decl.[1] (hr)	GE Decl.[1] (hr)	Basis (Referencing Criteria from the Reference Plant EAL Thresholds and Bases Guidelines)
SD01 SD01.1 through SD01.13	~5	11	11.5	• Alert: Loss of RCS inventory and RCS temperature exceeding 200 ºF will apply starting at ~9 hours; based on the simulation results. Elevated RCS temperature conditions briefly apply around t=30 minutes, and temperatures are close to exceeding 200 ºF thereafter; it is assumed that an ALERT is declared at the mid-point of this time window, based on ED discretion. • SAE: RPV level at top of active fuel with containment closure established • GE: Containment sump level rise, RPV level less than top of active fuel for greater than 30 minutes, and containment closure established with containment pressure greater than 3 psig
SD02	~20	n/a	n/a	• Alert: RCS temperature > 200F for >20 minutes, containment closed, and RCS integrity not established. • SAE: Site Area conditions are never met. • GE: General Emergency conditions are never met.
SD03 SD03.1	<1	~26	~33	• Alert: Loss of all offsite and onsite ac sources for greater than 15 minutes. • SAE: Declaration of Site Area Emergency (SAE) is difficult to predict, in that all indication is lost after 4 hours, preventing further assessment of plant conditions (containment is closed early). Gravity drain is assumed to start at 26 hours, under the assumption that via calculations or limited instrumentation restoration, operators are aware that the bulk refueling cavity water temperature has reached 100C, and significant water loss from evaporation has been occurring. Here, it is assumed that SAE is declared at this time, under ED discretion. • GE: Similar to the above, there is a high degree of uncertainty upon when the declaration would be made under blackout conditions (neither SAE nor GE have a criterion during shutdown equivalent to the Alert criterion cited above). Here, it is assumed that GE is declared upon RWST depletion, at 33 hours. Earlier or later declaration is certainly plausible given the extended lack of all instrumentation.

(Continued on next page)

Table 3-3 Preliminary Reactor-At-Shutdown EAL Classifications (cont.)

Rep. Seq. No.	Alert Decl.[1] (hr)	SAE Decl.[1] (hr)	GE Decl.[1] (hr)	Basis (Referencing Criteria from the Reference Plant EAL Thresholds and Bases Guidelines)
SD04	<1	~91	>168	• Alert: Loss of all offsite and onsite ac sources for greater than 15 minutes. • SAE: Declaration of Site Area Emergency (SAE) is difficult to predict, in that all indication is lost after 4 hours, preventing further assessment of plant conditions (containment is closed early). Gravity drain is assumed to start at 91 hours, under the assumption that via calculations or limited instrumentation restoration, operators are aware that the bulk refueling cavity water temperature has reached 100 ºC, and significant water loss from evaporation has been occurring. Here, it is assumed that SAE is declared at this time, under ED discretion. • GE: Similar to the above, there is a high degree of uncertainty upon when the declaration would be made under blackout conditions (neither SAE nor GE have a criterion during shutdown equivalent to the Alert criterion cited above). Here, it is assumed that GE is not declared prior to the end of the simulation.
SD05	<1	~6	~48	• Alert: Loss of all offsite and onsite ac sources for greater than 15 minutes • SAE: Declaration of Site Area Emergency (SAE) is difficult to predict, in that all indication is lost after four hours, preventing further assessment of plant conditions (though the open containment hatch will make it obvious that significant inventory loss is occurring). Here, it is assumed that SAE is declared at six hours, under ED discretion, when significant steam would be exiting the open hatch. • GE: Similar to the above, there is a high degree of uncertainty upon when the declaration would be made under blackout conditions (neither SAE nor GE have a criterion during shutdown equivalent to the Alert criterion cited above). Here, it is assumed that GE is declared via ED discretion based on extended boiling with (i) no compensating injection and (ii) containment open. A time of 48 hours is assumed. Earlier or later declaration is certainly plausible given the extended lack of all instrumentation.
SD06	~8	n/a	n/a	• Alert: RCS pressure increasing greater than 10 psig • SAE: Site Area conditions are never met. • GE: General Emergency conditions are never met.
SD06.1	~8	~25	~38	• Alert: RCS pressure increasing greater than 10 psig • SAE: RCS level <72% RVLIS with containment closure not established. • GE: Unexplained containment sump level rise, RPV level >63% for >30 minutes, and containment closure not established

Table 3-3 Preliminary Reactor-At-Shutdown EAL Classifications (cont.)

Rep. Seq. No.	Alert Decl.[1] (hr)	SAE Decl.[1] (hr)	GE Decl.[1] (hr)	Basis (Referencing Criteria from the Reference Plant EAL Thresholds and Bases Guidelines)
SD07 SD07.1 SD07.2	<1	~10	~15	• Alert: Loss of all offsite and onsite ac sources for greater than 15 minutes • SAE: Declaration of Site Area Emergency (SAE) is difficult to predict, in that all indication is lost after four hours, preventing further assessment of plant conditions (though the open containment hatch will make it obvious that significant inventory loss is occurring). Here, it is assumed that SAE is declared at 10 hours, under ED discretion, when significant steam would be exiting the open hatch. • GE: Similar to the above, there is a high degree of uncertainty upon when the declaration would be made under blackout conditions (neither SAE nor GE have a criterion during shutdown equivalent to the Alert criterion cited above). Here, it is assumed that GE is declared via ED discretion based on extended boiling with (i) no compensating injection and (ii) containment open. At around 15 hours, core damage is starting, which will also lead to increasing radiation doses near the open hatch. Earlier or later declaration is certainly plausible given the extended lack of all instrumentation.
SD08 SD08.1 SD08.2	~20	~20	~28	• Alert: Potential loss of the fuel clad barrier based on heat sink with SG narrow range level < 10% • SAE: Potential loss of the fuel clad barrier and RCS barrier based on heat sink with SG narrow range level < 10% • GE: Loss of fuel clad barrier based on core cooling with RVLIS < 41% and CETC > 711F; Loss of RCS Barrier based on high containment radiation readings due to ongoing fuel damage and cycling PORV; Potential loss of containment barrier based on core cooling conditions for > 15 minutes with RPV level < 63%
SD09	<1	~23	~24	• Alert: Loss of all offsite and onsite ac sources for greater than 15 minutes. • SAE: Declaration of Site Area Emergency (SAE) is difficult to predict, in that all indication is lost after four hours, preventing further assessment of plant conditions (containment is closed early). Gravity drain is assumed to start at 23 hours, under the assumption that via calculations or limited instrumentation restoration, operators are aware that the bulk refueling cavity water temperature has reached 100 ºC, and significant water loss from evaporation has been occurring. Here, it is assumed that SAE is declared at this time, under ED discretion. • GE: Similar to the above, there is a high degree of uncertainty upon when the declaration would be made under blackout conditions (neither SAE nor GE have a criterion during shutdown equivalent to the Alert criterion cited above). Here, it is assumed that GE is declared when the RWST gravity-feed becomes dead-headed and under the presumption that RWST level can be obtained, at 24 hours. Earlier or later declaration is certainly plausible given the extended lack of all instrumentation.

Table 3-3 Preliminary Reactor-At-Shutdown EAL Classifications (cont.)

Rep. Seq. No.	Alert Decl.[1] (hr)	SAE Decl.[1] (hr)	GE Decl.[1] (hr)	Basis (Referencing Criteria from the Reference Plant EAL Thresholds and Bases Guidelines)
SD10 SD10.1	~2.5	8	8.5	• Alert: RCS temperature greater than 200 ºF for greater than 20 minutes, with containment closure established and RCS integrity not established. • SAE: RPV level at top of active fuel with containment closure established • GE: Containment sump level rise, RPV level less than top of active fuel for greater than 30 minutes, and containment closure established with containment pressure greater than 3 psig.
SD11 SD11.1	~6	17	18	• Alert: RCS temperature greater than 200 ºF for greater than 20 minutes, with containment closure established and RCS integrity not established. – Earlier declaration might occur due to fluctuating temperatures around 200 ºF between two to six hours. • SAE: RPV level at top of active fuel with containment closure established. • GE: Containment sump level rise, RPV level less than top of active fuel for greater than 30 minutes, and containment closure established with containment pressure greater than 3 psig.
SD12 SD12.1	9	17	30	• Alert: RCS temperature greater than 200 ºF for greater than 20 minutes, with containment closure established and RCS integrity not established. • SAE: RPV level at top of active fuel with containment closure established. • GE: Likely via a combination of conditions with significant uncertainty: Containment sump level rise and RPV level less than top of active fuel for >30 minutes are met by 18 hours, but a containment challenge is also required; containment pressure hovers around the 3 psig threshold after ~30 hours; meanwhile, the 6% H2 limit is probably met soon before the 2nd large deflagration at ~49 hours or ED Discretion. 30 hours is selected as the GE declaration time as it is the earliest threshold reached.

(Continued on next page)

Table 3-3 Preliminary Reactor-At-Shutdown EAL Classifications (cont.)

Rep. Seq. No.	Alert Decl.[1] (hr)	SAE Decl.[1] (hr)	GE Decl.[1] (hr)	Basis (Referencing Criteria from the Reference Plant EAL Thresholds and Bases Guidelines)
SD13	<1	1	~5	• Alert: Loss of all offsite and onsite ac sources for greater than 15 minutes. • SAE: Declaration of Site Area Emergency (SAE) is difficult to predict, station blackout conditions may challenge plant indications, preventing further assessment of plant conditions (though the open containment hatch will make it obvious that significant inventory loss is occurring). Here, it is assumed that SAE is declared at one hour, under ED discretion, when significant steam would be exiting the open hatch. • GE: Similar to the above, there is a high degree of uncertainty upon when the declaration would be made under blackout conditions (neither SAE nor GE have a criterion during shutdown equivalent to the Alert criterion cited above). Here, it is assumed that GE is declared via ED discretion based on extended boiling with (i) no compensating injection and (ii) containment open. At around five hours, core damage is starting, which will also lead to increasing radiation doses near the open hatch. Earlier or later declaration is certainly plausible given the extended lack of all instrumentation.

Source: reproduced from Table 2-23 of NRC (2025)

1. Timings are relative to the time of occurrence of the initiating event.

Abbreviations: Rep. Seq. = representative sequence; Decl. = declaration; SAE = site area emergency; GE = general emergency; SD = shutdown; ED = Emergency Director; RPV = reactor pressure vessel; RVLIS = reactor vessel level instrumentation system; RCS = reactor coolant system; RWST = refueling water storage tank; SG = steam generator; CETC = core-exit thermocouple; PORV = power-operated relief valve

Table 3-4 Comparison of Preliminary GE Time to Release Timings

	Time (hr)					
	Reactor Shutdown Relative to Initiator[1]	Time of Initiator	Preliminary GE Declaration	Onset of Core Damage	Xe Release > 10%[2]	I Release > 1%[2]
SD01	-82	0	11.5	15	>168	>168
SD01.1	-82	0	11.5	15	>168	>168
SD01.2	-82	0	11.5	15	50	75
SD01.3	-82	0	11.5	15	40	80
SD01.4	-82	0	11.5	15	69	95
SD01.5	-82	0	11.5	15	>168	>168
SD01.6	-82	0	11.5	15	60	115
SD01.7	-82	0	11.5	15	70	155
SD01.8	-82	0	11.5	15	67	97
SD01.9	-82	0	11.5	15	72	110
SD01.10	-82	0	11.5	15	18	>168
SD01.11	-82	0	11.5	15	18	150
SD01.12	-82	0	11.5	15	30	55
SD01.13	-82	0	11.5	15	20	100
SD02	-501	0	>168	>168	>168	>168
SD03	-141	0	~33	125	132	128
SD03.1	-141	0	~33	125	133	128
SD04	-329	0	>168	>168	>168	>168
SD05	-141	0	~48	100	102	100
SD06	-526	0	>168	>168	>168	>168
SD06.1	-526	0	~38	~44	46	45
SD07	-12	0	~15	16	17	17
SD07.1	-12	0	~15	16	17	17
SD07.2	-12	0	~15	16	17	17
SD08	-5	0	~28	27	>168	>168
SD08.1	-5	0	~28	27	>33	>33
SD08.2	-5	0	~28	27	>168	>168
SD09	-141	0	~24	126	128	127
SD10	-141	0	8.5	10	>168	>168
SD10.1	-141	0	8.5	10	>168	>168
SD11	-12	0	18	21	>168	>168
SD11.1	-12	0	18	22	25	25
SD12	-507	0	30	24	>168	>168
SD12.1	-507	0	30	24	>168	>168
SD13	-55	0	~5	~5	7	7

Source: reproduced from Table 2-24 of NRC (2025)

1. This refers to how long the reactor has been shut down as of the time the accident initiating event occurs.

2. The timing of Xe and I releases are estimated from the descriptions of the MELCOR cases. More precise values can be obtained from the MELCOR output files as needed. The greater than symbol, e.g., >168, indicates the release fraction threshold was not reach by the end of the simulated calculation time, which was 168 hours for all calculations except case SD08.1 (calculation ended at 33 hours).

As discussed in Sections 2.5 and 2.7 of NRC (2025), each of these source terms is assigned to a release category. For situations where more than one source term could be assigned to a release category, the Level 2 PRA team selected a single source term to be used to represent the release category (which in this document is termed the *representative source term* for that release category), and identified the other source terms (which in this document are termed *alternate source terms*) that could be used to estimate the consequences from that release category.

In this analysis, each of the representative source terms was analyzed using the MACCS computer code. The base-case analyses only include the representative source terms. The alternate source terms are candidate source terms that could be analyzed as part of a sensitivity analysis (see, e.g., the potential sensitivity analysis identified as RE_3 in Table 3-13). Such a sensitivity analysis would allow an evaluation of the adequacy of the process for binning each of the MELCOR source terms into release categories and could serve to verify that the source term selected to represent each release category is appropriately representative. The list of MELCOR source terms, and the timing of the expected GE declaration for each, is summarized in Table 3-5.

Table 3-5 Release Category Summary Table for the Level 3 PRA Team

Release Category	Frequency (/yr)	Highest-Contributing POS	As-Modeled POS	MELCOR Case Identifier	GE Decl.	Warning Time Surrogate[1] (hr)	Cumul. Iodine Release[3]	Cumul. Cesium Release[3]	MELCOR Filename
ISLOCA	1.3E-7	5A (97%)	5A	SD11.1	18	7	5%	3%	SD11-1.ptf
ISGTR	<1E-12[2]	-	-	-	-	-	-	-	-
CIF	1.7E-6	8E (63%)	8E	SD03	~33	95	6%	7%	SD03.ptf
COPEN-RCSINTACT	2.7E-7	5A (62%)	5A	SD07	~15	2	38%	25%	SD07.ptf
COPEN-RCSVENT	1.3E-7	5B (56%)	5B	SD13	~5	2	82%	79%	SD13.ptf
COPEN-HEADOFF	7.8E-8	8E (100%)	8E	SD05	~48	52	88%	87%	SD05.ptf
ECF	5.1E-10	6 (55%)	6	SD01.2	11.5	~64	3%	1%	SD01-2.ptf
CF-Before-CD	2.1E-6	8E (100%)	8E	SD09	~24	103	14%	15%	SD09.ptf
ICF-BURN	1.7E-6	6 (48%)	6	SD01.8	11.5	~85	3%	6%	SD01-8.ptf
LCF	5.5E-8	5B (52%)	6	SD01	11.5	>156	<1%	<1%	SD01.ptf
BMT	1.2E-7	6 (25%)	3	SD08.2	~28	>140	<1%	<1%	SD08-2.ptf
NOCF	6.1E-6	8L (39%)	10	SD12	30	>138	<1%	<1%	SD12.ptf

Source: adapted from Table 2-74 of NRC (2025)

NOTE: POS: Plant Operating State; Decl.: Declaration; Cumul. Cumulative

1. This represents the delta between the preliminary GE declaration time and the earlier of the time of noble gas release >10% or iodine release >1%.

2. The frequency of this RC is below the model truncation limit of 1×10^{-12} per year. The induced steam generator tube rupture contribution is insignificant due to the limited reliance on steam generator cooling during shutdown POSs and during much of the outage steam generators are not available at all.

3. These values represent the fractions of mass of the chemical class from the core inventory released to the environment. The released activities, including effects of radionuclide decay during the time after reactor shutdown, are accounted for in the consequence analysis modeling.

3.1.2.2 Discussion of Source Term Characteristics Important for Level 3 PRA Analyses

The characteristics of the release categories traditionally considered most important to offsite consequences are the magnitude of the release and the warning time.

For the LPSD analysis, the release fraction is not always the best surrogate for the magnitude of the release. This is because (1) radioactive decay following reactor shutdown can result in significantly reduced inventories of short-lived radionuclides for accident initiation times that occur after reactor shutdown; and (2) accidents that occur after refueling, when one-third of the fuel assemblies have been replaced with fresh fuel, will release less activity than accidents that occur prior to refueling. Therefore, the release magnitudes discussed in this section are provided in terms of absolute activity released rather than release fraction. Because MACCS reports the total activity released by isotope as an intermediate output, that result was used to generate Table 3-6, showing the release magnitude as a function of both release fraction and release magnitude.[5] In this table, the cesium release magnitude is the sum of the released activity for radionuclides Cs-134, Cs-136, and Cs-137, and the iodine release magnitude is the sum of the released activity for I-131, I-132, I-133, I-134, and I-135. Table 3-6 also provides the release category frequency, the timing of the reactor trip (relative to accident initiation), and the warning time. The warning time is defined in Table 3-6 as the time available between the declaration of a GE and the onset of a major release. The onset of a major release is defined as the time at which the cumulative release of the noble gas release class exceeds 10 percent or the time at which the cumulative release of the iodine class exceeds 1 percent, whichever is shorter. The values for these properties were provided in Table 3-4. It can be seen from Table 3-6 that, for example, the cesium release magnitude is approximately linear with respect to the cesium release fraction. In contrast, the iodine release magnitude is less well correlated to the iodine release fraction. Although the largest iodine release fraction is observed in release category SD-COPEN-HEADOFF, this release is initiated 141 hours after shutdown and is the third largest iodine release. The largest iodine release arises from release category SD-COPEN-RCSVENT, which is initiated 55 hours after shutdown, and the second largest iodine release arises from release category SD-COPEN-RCSINTACT, which is initiated 12 hours after shutdown.

The contribution of release categories to the frequency-weighted release magnitude is shown in Figure 3-1 and Figure 3-2 for cesium and iodine, respectively. On a frequency-weighted basis, the significant contributors to cesium release comprise release categories SD-CF-Before-CD (46%), SD-CIF (16%), SD-COPEN-RCSVENT (15%), SD-COPEN-RCSINTACT (10%), and SD-COPEN-HEADOFF (10%). The same release categories are important to the iodine release magnitude, but with a different relative ranking. They include SD-COPEN-RCSINTACT (32%), SD-COPEN-RCSVENT (28%), SD-CF-Before-CD (21%), SD-CIF (7%), and SD-COPEN-HEADOFF (6%).

[5] The details of how the core inventories were calculated are summarized in Section 3.1.2.3 and the details of how the source term files were processed using MELMACCS are described in Section 3.1.2.6.

Table 3-6 Cumulative Release of Cesium (Cs) and Iodine (I) Classes at the End of the Simulation

Release Category	Source Term	Frequency (per yr)	Time of Reactor Trip Relative to Accident Initiation (hr)	Warning Time (hr)	Cumulative Release (%) at End of Simulation		Cumulative Release (MCi) at End of Simulation	
					Cs	I	Cs	I
SD-ISLOCA	SD11.1	1.30E-07	-12	7	2.8	4.5	0.797	8.31
SD-CIF	SD03	1.70E-06	-141	95	6.7	5.9	1.81	2.61
SD-COPEN-RCSINTACT	SD07	2.70E-07	-12	2	24.9	38.2	7.11	70.6
SD-COPEN-RCSVENT	SD13	1.30E-07	-55	2	78.9	81.5	22.4	126.1
SD-COPEN-HEADOFF	SD05	7.80E-08	-141	52	86.5	87.9	23.5	44.7
SD-ECF	SD01.2	5.10E-10	-82	~64	1.1	3.0	0.297	1.62
SD-CF-Before-CD	SD09	2.10E-06	-141	103	15.4	13.7	4.18	6.07
SD-ICF-BURN	SD01.8	1.70E-06	-82	~85	0.6	2.7	0.156	1.41
SD-LCF	SD01	5.50E-08	-82	>156	<0.1	<0.1	5.15E-04	2.01E-03
SD-BMT	SD08.2	1.20E-07	-5	>140	<0.1	<0.1	4.71E-05	5.24E-04
SD-NOCF	SD12	6.10E-06	-507	>138	<0.1	<0.1	2.59E-04	1.42E-04

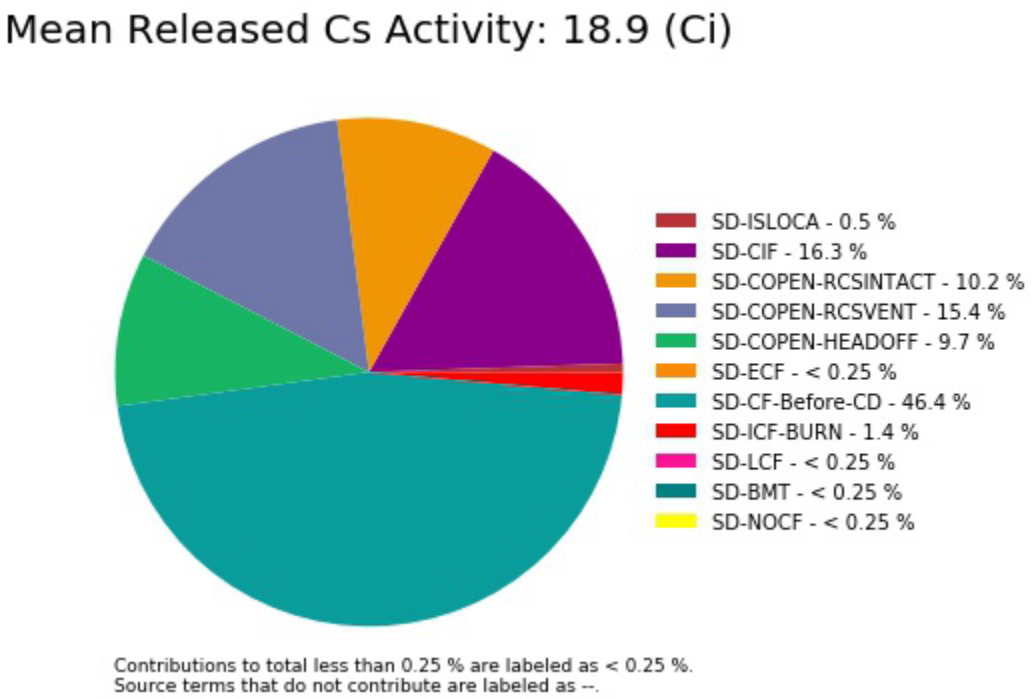


Figure 3-1 Relative Contribution of Release Categories to Frequency-Weighted Mean Cesium Release Magnitude

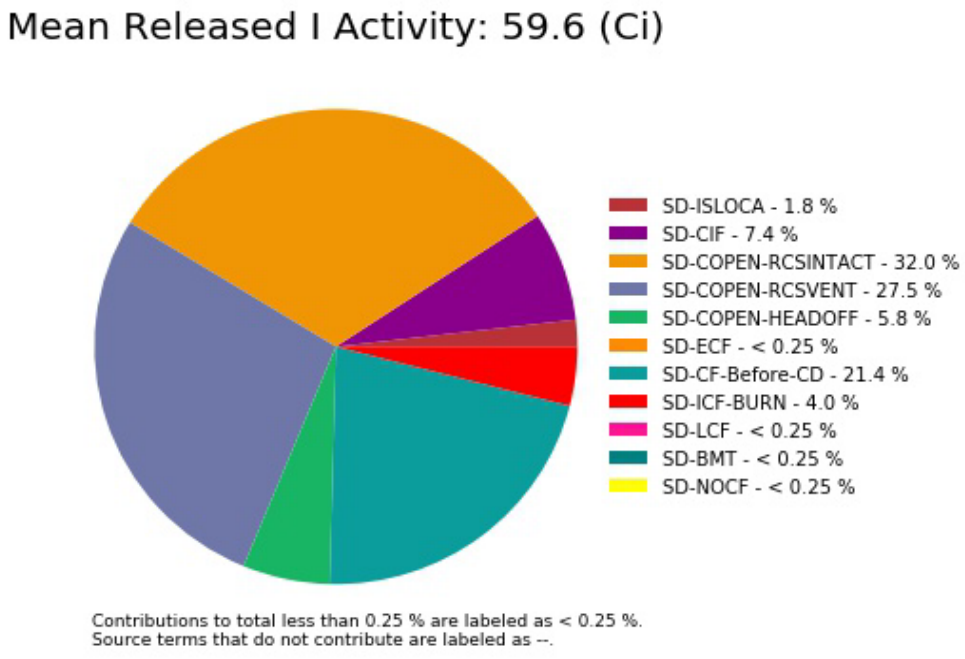


Figure 3-2 Relative Contribution of Release Categories to Frequency-Weighted Mean Iodine Release Magnitude

For the LPSD analysis, the warning time is particularly uncertain because the time at which a GE is declared is subject to considerable uncertainty for several release categories, as discussed in Table 3-3 of this report and in Section 2.5.2 of NRC (2025). Several of the release categories (SD-CIF, SD-COPEN-RCSINTACT, SD-COPEN-RCSVENT, SD-COPEN-HEADOFF, and SD-CF-Before-CD) are modeled as station blackouts for which there is no GE criterion during shutdown equivalent to the prolonged loss of all offsite and all onsite AC power criterion that applies during at-power operations. For the LPSD analysis it is therefore assumed that GE is declared via Emergency Director discretion for such release categories. For three of these release categories (SD-CIF, SD-COPEN-HEADOFF, and SD-CF-Before-CD), the accident is initiated almost 6 days after shutdown and the GE declarations in Table 3-4 are projected 2 or more days before the onset of core damage. In contrast, the source term for SD-COPEN-RCSINTACT is initiated 12 hours after shutdown and the GE declaration in Table 3-4 is projected to occur around the same time as core damage, with 2 hours before the onset of a major release. The source term for SD-COPEN-RCSVENT is initiated 55 hours (a little over 2 days) after shutdown and the GE declaration in Table 3-4 is projected to occur at the same time as core damage and 2 hours before the onset of a major release. In addition, the same considerations apply related to the inherent uncertainty in estimating a single warning time discussed in Section 3.1.2.2 of NRC (2022a); namely,

- cohorts beyond the EPZ may be assumed to receive an evacuation order after GE
- the keyhole evacuation model used in this analysis will not trigger an evacuation order for areas outside the circular portion of the keyhole until several hours before the wind is projected to shift
- some source terms may exhibit a period of low-level releases before the onset of the major release
- other source terms may never result in a large release

Nevertheless, the characterization of the warning time as discussed above remains a useful heuristic for evaluating the potential for an early release.

Three release categories are modeled with warning times less than 24 hours. Release category SD-COPEN-RCSVENT, which is initiated 55 hours after reactor trip, has the largest iodine release (126 MCi) and a 2-hour warning time. Release category SD-COPEN-RCSINTACT, which is initiated 12 hours after reactor trip, has the second highest iodine release (71 MCi) and also has a 2-hour warning time. Release category SD-ISLOCA is initiated 12 hours after reactor trip but has the fifth largest iodine release (2.6 MCi) and a 7-hour warning time, which is longer than the expected 3–4 hour evacuation time estimate

It may be noted, as discussed previously, that the timing of a GE declaration (and therefore the estimated warning time) is relatively uncertain for several of these release categories. However, most of these release categories involve relatively slowly progressing accidents, with several days between accident initiation and the onset of a major release (defined as either 10 percent noble gas release fraction or 1 percent iodine). Three release categories (SD-ECF, SD-ICF-BURN, and SD-LCF) are notable in that while they proceed to core damage in less than 1 day, there is well over a day between the onset of core damage and the onset of a major release. As will be discussed later, this has implications for the proper parameterization of the MACCS

early-phase relocation model, which is triggered based on a dose estimated over a fixed projection period from the arrival time of the first plume segment at a location.

The time dependence of the release is illustrated by plotting the release magnitude as a function of time for each of the release categories. This is plotted against three different time scales. In Figure 3-3, the cumulative cesium release magnitude is plotted against the (a) time since shutdown, (b) time since initiating event, and (c) time since GE declaration. In Figure 3-4, the cumulative iodine release magnitude is plotted against the (a) time since shutdown, (b) time since initiating event, and (c) time since GE declaration. The top curve shows the release as a function of time since shutdown and reflects the MACCS inputs, which were adjusted for time since shutdown to properly account for radioactive decay. The middle curve, showing the release as a function of time since accident initiation, is more representative of the MELCOR modeling of accident progression, which is normalized to the time of accident initiation. The final curve, which represents the warning time, is generated by subtracting the GE time for each scenario from its time of release. All curves represent the results of the 168-hour MELCOR modeling time (most clearly seen in the middle figure), but because some releases start at different times than others, the release duration (relative to onset of release) is different for different source terms. It may be seen that whereas the highest cesium release in Figure 3-3 occurs in the middle of the shutdown period, the iodine releases shown in Figure 3-4 become steadily lower as the time since shutdown increases.

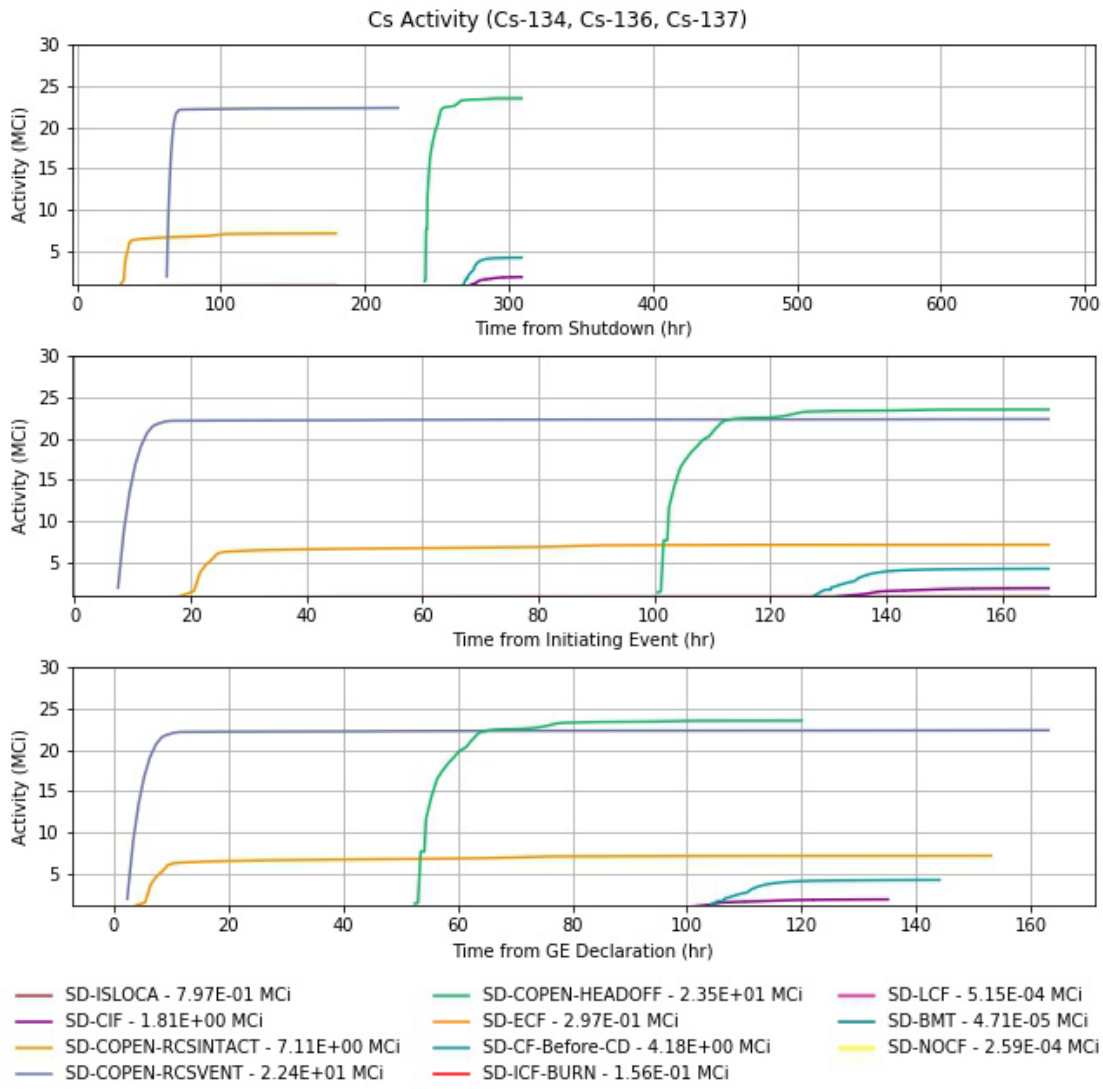


Figure 3-3 Cesium Release Magnitude as a Function of (a) Time since Shutdown, (b) Time since Initiating Event, and (c) Time since GE Declaration

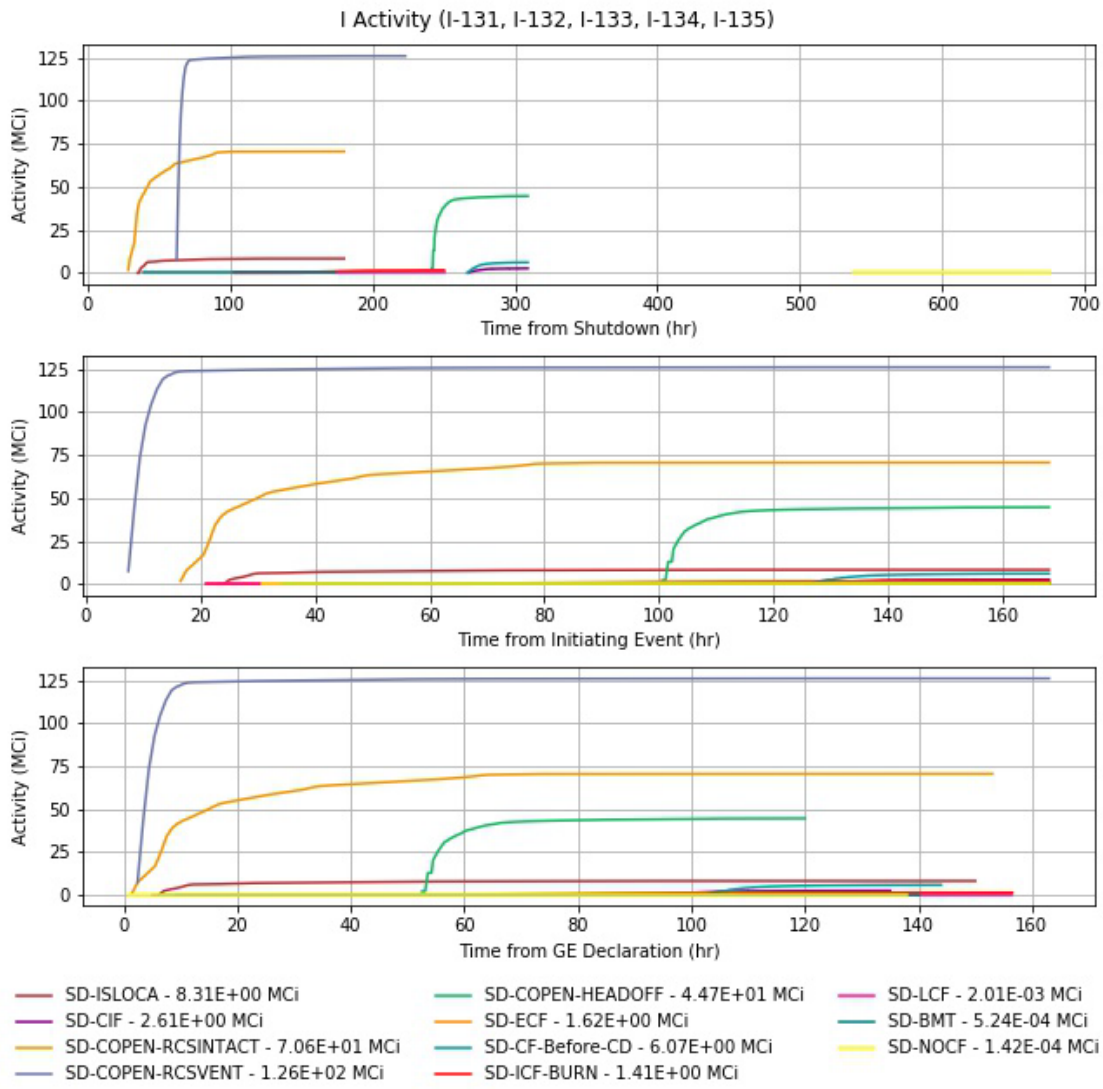


Figure 3-4 Iodine Release Magnitude as a Function of (a) Time since Shutdown, (b) Time since Initiating Event, and (c) Time since GE Declaration

3.1.2.3 Identification of Radionuclides and Development of Initial Radionuclide Inventory

For the LPSD analysis, no changes were made to the identification of radionuclides discussed in Section 3.1.2.3 of NRC (2022a). However, the core inventories for the LPSD analysis are different from those used for the at-power analyses documented in NRC (2022a). Rather than a trip during middle of cycle from 100 percent power, the core inventories are based on shutdown following a period of coastdown. Decay and ingrowth of radioactivity following shutdown was modeled by defining the core inventory for MACCS based on the initial shutdown activity and adding the time between shutdown and accident initiation (given in Table 3-4) to the MACCS timeline variables PDELAY and DLTSHL. Because MACCS accounts for decay and ingrowth, this obviates the need to develop a core inventory that is specific to each source term, as each source term may have a different offset between shutdown and accident initiation. Furthermore, one release category (SD-NOCF, modeled as POS 10 with Case SD12) was modeled as occurring after refueling of the core. This release category will therefore have a lower initial radiological inventory because the radioactivity associated with the assemblies discharged to the spent fuel pool will no longer be present in the core. As noted in Section 2.7 of NRC (2025):

> "In the at-shutdown analysis, release category frequencies are calculated outage-wide, and then evaluated to obtain the contributions from individual POSs. Meanwhile, the MELCOR source terms are generated assuming that the initiating event occurs at a particular point in the outage. Thus, the consequence analysis will need to consider what accident timing after shutdown (and thus initial core inventory) is most appropriate when utilizing the time-dependent MELCOR release fractions. … The release categories of most concern in this regard are those where the frequency contribution is spread across more than one POS (i.e., is more diffuse): 1-REL-SD-BMT, 1-REL-SD-ICF-BURN, 1-REL-SD-LCF, and 1 REL-SD-NOCF."

For the Level 3 PRA analysis, it was determined that it was most appropriate to develop a core inventory that was consistent with the MELCOR inventories used to generate the source terms. The core radiological inventories based upon the corrected MelMACCS inventory files are shown in Table 3-7. The values used for at-power initiating events, which assumed a trip from 100 percent power during middle-of-cycle, are also provided for reference.

Table 3-7 Initial Core Inventories (Bq)

Nuclide	Coastdown, All Assemblies (Pre-Refueling)	Coastdown, Refueled Assemblies Only[1]	MOC Trip from 100% Power
Kr-85	3.64E+16	1.97E+16	2.75E+16
Kr-85m	2.78E+17	1.50E+17	1.07E+18
Kr-87	5.18E+17	2.80E+17	2.13E+18
Kr-88	6.89E+17	3.72E+17	2.82E+18
Xe-133	7.11E+18	3.84E+18	7.54E+18
Xe-135	1.52E+18	8.18E+17	1.89E+18
Xe-135m	5.25E+17	2.83E+17	1.56E+18
Cs-134	5.65E+17	3.05E+17	3.30E+17
Cs-136	1.36E+17	7.32E+16	9.52E+16
Cs-137	3.69E+17	1.99E+17	2.63E+17
Rb-86	7.96E+15	4.30E+15	5.32E+15
Rb-88	7.41E+17	4.00E+17	2.86E+18
Ba-139	1.78E+18	9.59E+17	6.76E+18
Ba-140	5.99E+18	3.23E+18	6.53E+18
Sr-89	3.40E+18	1.83E+18	3.92E+18
Sr-90	2.71E+17	1.46E+17	2.03E+17
Sr-91	1.71E+18	9.25E+17	4.88E+18
Sr-92	1.31E+18	7.08E+17	5.19E+18
Ba-137m	3.50E+17	1.89E+17	2.51E+17
I-131	3.38E+18	1.82E+18	3.57E+18
I-132	4.40E+18	2.37E+18	5.32E+18
I-133	4.40E+18	2.38E+18	7.47E+18
I-134	2.33E+18	1.26E+18	8.49E+18
I-135	2.36E+18	1.28E+18	7.13E+18
Te-127	2.84E+17	1.53E+17	2.79E+17
Te-127m	2.45E+16	1.32E+16	2.27E+16
Te-129	3.49E+17	1.89E+17	8.85E+17
Te-129m	1.37E+17	7.39E+16	1.30E+17
Te-131m	4.73E+17	2.56E+17	6.40E+17
Te-132	4.27E+18	2.30E+18	5.13E+18
Te-131	9.48E+17	5.12E+17	3.10E+18
Rh-105	2.76E+18	1.49E+18	2.87E+18
Ru-103	5.54E+18	2.99E+18	5.06E+18
Ru-105	1.16E+18	6.28E+17	3.28E+18
Ru-106	1.74E+18	9.40E+17	1.18E+18

Table 3-7 Initial Core Inventories (Bq) (cont.)

Nuclide	Coastdown, All Assemblies (Pre-Refueling)	Coastdown, Refueled Assemblies Only[1]	MOC Trip from 100% Power
Rh-103m	5.48E+18	2.96E+18	5.01E+18
Rh-106	1.81E+18	9.78E+17	1.42E+18
Nb-95	6.29E+18	3.40E+18	6.25E+18
Co-58	3.92E+07	2.12E+07	2.33E+07
Co-60	4.57E+11	2.47E+11	2.35E+11
Mo-99	5.45E+18	2.94E+18	6.84E+18
Tc-99m	5.09E+18	2.75E+18	6.28E+18
Nb-97	3.46E+18	1.87E+18	6.56E+18
Nb-97m	3.18E+18	1.72E+18	6.20E+18
Ce-141	5.83E+18	3.15E+18	6.12E+18
Ce-143	3.83E+18	2.07E+18	5.86E+18
Ce-144	4.38E+18	2.37E+18	3.79E+18
Np-239	5.61E+19	3.03E+19	6.46E+19
Pu-238	8.84E+15	4.78E+15	4.67E+15
Pu-239	1.08E+15	5.84E+14	9.51E+14
Pu-240	1.53E+15	8.27E+14	1.07E+15
Pu-241	4.16E+17	2.25E+17	2.79E+17
Zr-95	6.17E+18	3.33E+18	6.42E+18
Zr-97	3.34E+18	1.80E+18	6.52E+18
Am-241	4.18E+14	2.26E+14	2.67E+14
Cm-242	1.29E+17	6.99E+16	6.61E+16
Cm-244	1.03E+16	5.58E+15	3.74E+15
La-140	6.33E+18	3.42E+18	6.64E+18
La-141	1.74E+18	9.38E+17	6.17E+18
La-142	1.55E+18	8.38E+17	5.98E+18
Nd-147	2.20E+18	1.19E+18	2.39E+18
Pr-143	5.45E+18	2.94E+18	5.87E+18
Y-90	2.81E+17	1.52E+17	2.11E+17
Y-91	4.47E+18	2.42E+18	5.01E+18
Y-92	1.42E+18	7.66E+17	5.25E+18
Y-93	2.18E+18	1.18E+18	5.80E+18
Y-91m	1.04E+18	5.59E+17	2.88E+18
Pr-144	4.40E+18	2.37E+18	3.83E+18
Pr-144m	4.89E+16	2.64E+16	6.03E+16

[1] The activity represents the activity at shutdown of the assemblies that are reloaded into the core during refueling.

3.1.2.4 Chemical Class Assignments

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.1.2.5 Aerosol Characteristics

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis. However, because the particle-size distribution data is source-term-dependent, the values are different from those used in the reactor at-power analysis. The particle-size distribution data for each chemical class and each release category used in the LPSD analysis are provided in Table A.1c of Appendix A.

3.1.2.6 Plume Release Path Characterization

The MACCS atmospheric dispersion models, discussed in more detail in Section 3.3 of this document, require specification of the elevation of the release (PLHITE), as well as the building height (BUILDH) and initial plume height (PLSIGYINIT) and width (PLSIGZINIT). These parameters are characteristics of the physical location of the release path modeled in MELCOR and are summarized in Table 2-77 of NRC (2025). As summarized in Table 3-8 of this document, there are several potential locations where radioactivity could be released to the environment in the case of a severe accident. The flow paths are generally consistent with the flow paths for the at-power analyses (see NRC (2022b) and Table 3.1-10 of NRC 2022a), but additional flow paths were added for the LPSD analysis to account for potential releases through open equipment and personnel hatches. The approach to estimating the effective building dimensions used to estimate the initial plume height (PLSIGYINIT) and width (PLSIGZINIT), as well as the elevation of the release (PLHITE), is consistent with the discussion in Section 3.1.2.6 of NRC (2022a) and is not reproduced here.

Table 3-8 Description of Release Points from MELCOR Modeling

Description	Location	MELCOR Release Paths	Effective Building Dimensions	Elevation of Release (m)
SG 1 SRV tailpipe	South Main Steam Valve Room Roof	372	Containment, 45m x 55m	13m
SG 1 SRV tailpipe	South Main Steam Valve Room Roof	373	Containment, 45m x 55m	13m
SG 1 SRV tailpipe	South Main Steam Valve Room Roof	374	Containment, 45m x 55m	13m
SG 1 SRV tailpipe	South Main Steam Valve Room Roof	375	Containment, 45m x 55m	13m
SG 1 lowest Setpoint SRV tailpipe	South Main Steam Valve Room Roof	376	Containment, 45m x 55m	13m
SG 1 ARV tailpipe	South Main Steam Valve Room Roof	377	Containment, 45m x 55m	13m
SG 1 PORV leakage	South Main Steam Valve Room Roof	379	Containment, 45m x 55m	13m
SG 2 SRV tailpipe	North Main Steam Valve Room Roof	472	Containment, 45m x 55m	13m
SG 2 SRV tailpipe	North Main Steam Valve Room Roof	473	Containment, 45m x 55m	13m
SG 2 SRV tailpipe	North Main Steam Valve Room Roof	474	Containment, 45m x 55m	13m
SG 2 SRV tailpipe	North Main Steam Valve Room Roof	475	Containment, 45m x 55m	13m
SG 2 lowest Setpoint SRV tailpipe	North Main Steam Valve Room Roof	476	Containment, 45m x 55m	13m
SG 2 ARV tailpipe	North Main Steam Valve Room Roof	477	Containment, 45m x 55m	13m
SG 2 PORV leakage	North Main Steam Valve Room Roof	479	Containment, 45m x 55m	13m
SG 3 SRV tailpipe	North Main Steam Valve Room Roof	572	Containment, 45m x 55m	13m
SG 3 SRV tailpipe	North Main Steam Valve Room Roof	573	Containment, 45m x 55m	13m
SG 3 SRV tailpipe	North Main Steam Valve Room Roof	574	Containment, 45m x 55m	13m
SG 3 SRV tailpipe	North Main Steam Valve Room Roof	575	Containment, 45m x 55m	13m
SG 3 lowest setpoint SRV tailpipe	North Main Steam Valve Room Roof	576	Containment, 45m x 55m	13m
SG 3 ARV tailpipe	North Main Steam Valve Room Roof	577	Containment, 45m x 55m	13m
SG 3 PORV leakage	North Main Steam Valve Room Roof	579	Containment, 45m x 55m	13m
SG 4 SRV tailpipe	South Main Steam Valve Room Roof	672	Containment, 45m x 55m	13m
SG 4 SRV tailpipe	South Main Steam Valve Room Roof	673	Containment, 45m x 55m	13m
SG 4 SRV tailpipe	South Main Steam Valve Room Roof	674	Containment, 45m x 55m	13m
SG 4 SRV tailpipe	South Main Steam Valve Room Roof	675	Containment, 45m x 55m	13m
SG 4 lowest setpoint SRV tailpipe	South Main Steam Valve Room Roof	676	Containment, 45m x 55m	13m

(Continued on next page)

Table 3-8 Description of Release Points from MELCOR Modeling (cont.)

Description	Location	MELCOR Release Paths	Effective Building Dimensions	Elevation of Release (m)
SR 4 ARV tailpipe	South Main Steam Valve Room Roof	677	Containment, 45m x 55m	13m
SG 4 PORV leakage	South Main Steam Valve Room Roof	679	Containment, 45m x 55m	13m
Fuel handling building exhaust	Plant Stack	991	Containment, 45m x 55m	21m
Piping penetration area filtration and exhaust system exhaust (through the plant stack)	Plant Stack	027	Containment, 45m x 55m	55m
Normal Containment Leakage	Containment*	820	Containment, 45m x 55m	42m
Normal Containment Leakage	Containment*	821	Containment, 45m x 55m	25m
Normal Containment Leakage	Containment*	824	Containment, 45m x 55m	16m
Containment Overpressure	Containment***	841	Containment, 45m x 55m	0m
Containment Overpressure	Containment***	842	Containment, 45m x 55m	0m
Normal Aux Building Leakage	Aux Building*	997	Aux Building**, 38m x 14m	0m
Normal Aux Building Leakage	Aux Building*	998	Aux Building**, 38m x 14m	6m
Tendon gallery access shafts (2 of 3)	Aux Building*	844	Aux Building**, 38m x 14m	0m
Aux Building Overpressure	Aux Building*	995	Aux Building**, 38m x 14m	11m
Fuel handling building ventilation intakes, exhausts, and leaks	Containment*	910	Containment, 45m x 55m	21m
Fuel handling building ventilation intakes, exhausts, and leaks	Containment*	920	Containment, 45m x 55m	21m
Fuel handling building ventilation intakes, exhausts, and leaks	Containment*	930	Containment, 45m x 55m	21m
Fuel handling building ventilation intakes, exhausts, and leaks	Containment*	940	Containment, 45m x 55m	10m
Fuel handing building sliding door	Containment*	941	Containment, 45m x 55m	2m
Equipment hatch	Containment	9599	Containment, 45m x 55m	1m
Equipment hatch	Containment	9609	Containment, 45m x 55m	4m
Personnel hatch	Containment	9851	Containment, 45m x 55m	2m

(Continued on next page)

Table 3-8 Description of Release Points from MELCOR Modeling (cont.)

Description	Location	MELCOR Release Paths	Effective Building Dimensions	Elevation of Release (m)
Personnel hatch	Containment	9852	Containment, 45m x 55m	2m
RWST vent	Containment	1310	Containment, 45m x 55m	18m
Containment overpressure failure path	Containment***	7824	Containment, 45m x 55m	0m

Source: adapted from Table 2-77 in NRC (2025)

** Precise failure location not specified – source can be distributed over the surface area of the structure or located at any point on the structure*

*** Dimensions of auxiliary building from Section F.3.4 of the site environmental report*

**** Note that the location is quite uncertain. Releases could occur from multiple locations with elevations ranging from 0-18 m above grade from a variety of structures.*

3.1.2.7 Plume Segment Definitions

The approach to defining plume segments of approximately 1-hour duration is described in Section 3.1.2.7 of NRC (2022a) and is not reproduced here. However, the resulting values are different because the MELCOR-generated source terms are different. A summary of the MELCOR-generated source terms, including the number of plume segments and value of MAXRIS for each case, is given in Table 3-9. The onset of release is based on the MACCS variable PDELAY001 but is given relative to accident initiation time by subtracting the elapsed time between shutdown and accident initiation from the value for PDELAY001. The onset of a major release (defined as either 10 percent noble gas release fraction or 1 percent iodine), relative to accident initiation, is also provided. The values used to estimate these are provided in Table 3-4. A summary of key accident progression event timings is provided in Table 3-10. The complete plume segment definition for all cases, including the values for the release pathway, plume heat, density, flow rate, and release fraction for each plume segment, is included in Appendix A under Tables A.1a and A.1b. Those references contain detailed information on the methods and inputs used by MelMACCS to convert the information from MELCOR into a form suitable for use in MACCS.

Table 3-9 Summary of MACCS Source Terms

Release Category	MELCOR Modeling Case	NUMREL	MAXRIS	GE (hr)	Onset of Release (hr)[1]	Onset of Major Release (hr)[1]	Cs Release Fraction	I Release Fraction	MELCOR File
ISLOCA	SD11.1	207	4	18	22	25	3%	5%	SD11-1.ptf
CIF	SD03	64	4	~33	125	128	7%	6%	SD03.ptf
COPEN-RCSINTACT	SD07	139	6	~15	15.6	17	25%	38%	SD07.ptf
COPEN-RCSVENT	SD13	166	1	~5	6.4	7	79%	82%	SD13.ptf
COPEN-HEADOFF	SD05	74	3	~48	99.4	100	87%	88%	SD05.ptf
ECF	SD01.2	191	13	11.5	15.0	50	1%	3%	SD01-2.ptf
CF-Before-CD	SD09	52	13	~24	124.4	127	15%	14%	SD09.ptf
ICF-BURN	SD01.8	124	23	11.5	15.1	67	6%	3%	SD01-8.ptf
LCF	SD01	222	11	11.5	15.0	>168	<1%	<1%	SD01.ptf
BMT	SD08.2	72	1	~28	28.3	>168	<1%	<1%	SD08-2.ptf
NOCF	SD12	203	5	30	24.9	>168	<1%	<1%	SD12.ptf

1. All times are relative to accident initiation.

Table 3-10 Summary of Key Event Timings for MACCS Source Terms

Release Category	Seq	Time of Reactor Trip (hr)	T_{clad} MAX > 1478K	Vessel Breach (hr)	Time to Enter SCG-1, >102 psig (hr)	Time of Containment Failure (hr)	Cause of Containment Failure	MAXRIS Plume Segment (hr)
SD-ISLOCA	SD11.1	-12	21	30	N/A	n/a	BY	24
SD-CIF	SD03	-141	125	137	N/A	Early	Un-isol.	125
SD-COPEN-RCSINTACT	SD07	-12	15	21	N/A	Early	Open	17
SD-COPEN-RCSVENT	SD13	-55	7	14	N/A	Early	Open	14
SD-COPEN-HEADOFF	SD05	-141	100	110	N/A	Early	Open	101
SD-ECF	SD01.2	-82	15	24	N/A	24	F:VB	35
SD-CF-Before-CD	SD09	-141	125	135	106	118	OP	130
SD-ICF-BURN	SD01.8	-82	15	25	N/A	60	F:VB+35	64
SD-LCF	SD01	-82	15	24	151	168	OP	27
SD-BMT	SD08.2	-5	28	32	N/A	165	BMT	28
SD-NOCF	SD12	-507	24	56	N/A	n/a	n/a	31

Note: All times are relative to accident initiation.

3.1.3 MACCS Radionuclide Release Input Parameter Summary

A summary of the MACCS input parameters for radionuclide release characterization is provided in Table 3-11.

Table 3-11 Summary of MACCS Inputs Related to Radionuclide Release Characterization

MACCS Input Parameters Variable	Description	Value	Source
ATNAM1	Title Describing the ATMOS Assumptions		
ATNAM2	Title Describing the Source Term		
MSMODL	Multisource Model Flag	FALSE	
NUMISO	Number of Radionuclides	69	Section 3.1.2.3
NUCNAM	Radionuclide Names	Table 3.1-5 of NRC (2022a)	
NUMSTB	Number of Pseudostable Radionuclides	16	
NAMSTB	List of Pseudostable Nuclides	Table 3.1-6 of NRC (2022a)	
CORINV	Isotopic Inventory at Time of Reactor Shutdown (Bq)	Table 3-7	
CORSCA	Linear Scaling Factor on Core Inventory	1.0	
APLFRC	Method of Applying Release Fraction	PARENT	
MAXGRP	Number of Radionuclide Groups	9	Section 3.1.2.4
GRPNAM	Names of the Radionuclide Groups	Table 3.1-8 of NRC (2022a)	
IGROUP	Definition of Radionuclide Group Numbers	Table 3.1-8 of NRC (2022a)	
NPSGRP	Number of Particle-Size Groups	10	Section 3.1.2.5
PSDIST	Particle-Size Distribution by Group	Table A.1c	
BUILDH	Building Height (m)	Table 3-17**	Section 3.1.2.6
PLHITE	Plume Release Height (m)	Table 3-17**	

(Continued on next page)

Table 3-11 Summary of MACCS Inputs Related to Radionuclide Release Characterization (cont.)

MACCS Input Parameters Variable	Description	Value	Source
NUMREL	Number of Released Plume Segments	Table 3-9	Section 3.1.2.7 Plume segment parameter values from MELCOR as segmented by MelMACCS based on duration and threshold definitions.
MAXRIS	Selection of Risk-Dominant Plume Segment	Table 3-9	
REFTIM	Plume Reference Time Point	0 for first 0.5 for subsequent	
PLHEAT*	Plume Heat Contents (W)	Table A.1a	
PLMDEN	Plume Mass Density (kg/m^3)	Table A.1a	
PLMFLA	Plume Mass Flow Rate (kg/s)	Table A.1a	
PDELAY	Plume Release Times (sec)	Table A.1a	
PLUDUR	Plume Segment Durations (sec)	Table A.1a	
RELFRC	Release Fractions of the Source Term	Table A.1b	

** Value is reported in table but not used; plume mass density and flow rate are used to compute buoyancy flux instead.*

*** Based on information in Table 3-8.*

3.1.4 Identification and Discussion of Uncertainties Related to Radionuclide Release Characterization

The following identification and discussion of uncertainties is adapted from NRC (2022a). It has been supplemented to recognize the additional uncertainty in the timing of EAL declarations and the uncertainty in the core inventory associated with accidents occurring at different times following shutdown.

There are several sources of uncertainty in the calculation that were identified by project staff. These are listed in Table 3-12, which was generated by reviewing each subsection to identify and characterize the sources of uncertainty. Table 3-13 provides a list of potential candidate sensitivity analyses based on a subset of the uncertainties identified in Table 3-12. A candidate sensitivity analysis has only been identified for those uncertainties that are considered readily amenable to quantitative modeling using MACCS.

Of all the uncertainties identified in Table 3-12, the uncertainties in accident progression or source term modeling that would propagate into the source terms used in the MACCS calculations are judged to be the most significant. The significance of these uncertainties is dependent upon the extent to which they change the source term characteristics, particularly in terms of release timing and magnitude. This is related to the fact that MELCOR source terms selected to represent release categories have to represent a spectrum of potential accidents from the Level 1 and Level 2 PRA, each of which may have different consequences. The existing source terms cover a wide range of release magnitudes and timings, such that alternate source terms are expected to be reasonably within the envelope of the existing source terms. However, the relative frequency of different source terms with different release timings and

magnitudes, and thus the integrated risk results, could change if there were significant differences in the relative frequency of the different scenarios.

The core inventory used in the calculation is a potential source of uncertainty, in that the point in the cycle assumed for the calculation can affect the inventory of fission products that can accumulate over the lifetime of the core. The current calculations are based on discrete times following shutdown that are consistent with the development of the MELCOR model. To the extent that these sequences occurred earlier or later following shutdown, the consequences could be affected by the increased (or decreased) radiological inventories associated with the decay of short-lived radioactivity. In addition, for release categories that can occur either before or after refueling, the inventory available for release can be either more or less than that modeled here. The core inventory associated with different times in the operating cycle would also give rise to differences in chemical inventories and decay heats, which would affect the accident progression characteristics. However, treatment of that aspect of inventory would require an integrated Level 2/Level 3 sensitivity analysis, which is beyond the scope of this analysis.

As discussed in Table 3-3 of this document and in Section 2.5.2 of NRC (2025), there is considerable uncertainty associated with the timing of GE declarations for station blackout scenarios for the LPSD analysis. During shutdown conditions, there is no GE criterion equivalent to the SG-1 (Prolonged loss of all offsite and all onsite AC power) criterion that applies during at-power operations. For the LPSD analysis it is therefore assumed that GE is declared via Emergency Director discretion (HG2) for such release categories. However, it should be noted that this would only be a significant source of uncertainty if the actual GE declaration were delayed for these release categories until the point that releases were imminent or were occurring (i.e., if it resulted in a warning time on the order of less than a few hours and did not provide sufficient time for evacuation of the EPZ). For three of these release categories (SD-CIF, SD-COPEN-HEADOFF, and SD-CF-Before-CD), the accident is initiated almost 6 days after shutdown and the GE declarations in Table 3-4 are projected to occur 2 or more days before the onset of core damage. Only a very delayed GE declaration would result in increased early-phase exposures from these release categories. Because this affects the modeling of protective actions, this uncertainty is also identified in Section 3.4.

Table 3-12 Uncertainties Related to Radionuclide Release Characterization

3.1.2.1 Transition from Level 2 to Level 3	Uncertainties in accident progression or source term modeling would propagate into the source terms used in the MACCS calculations. The significance of these uncertainties is dependent upon the extent to which they change the source term characteristics, particularly in terms of release timing and magnitude.
	MELCOR source terms selected to represent release categories have to represent a spectrum of potential accidents from the Level 1 and Level 2 PRA, each of which may have different consequences. The significance of these uncertainties depends on the relative likelihood of different accident progression scenarios.
	There is uncertainty in estimating the timing of GE declarations arising from station blackout sequences occurring during cold operating conditions. This is because there is no GE criterion during shutdown conditions that is equivalent to the SG-1 (Prolonged loss of all offsite and all onsite AC power) criterion that applies during at-power operations. For these scenarios it is therefore assumed that GE is declared via Emergency Director discretion (HG2). This uncertainty could be significant for early-phase exposures if the declaration of a GE were delayed sufficiently that the warning time was insufficient to allow evacuation of the EPZ prior to release. Because this affects the modeling of protective actions, this uncertainty is also identified in Section 3.4 and an associated sensitivity analysis is identified in Section 3.4.4.
3.1.2.3 Identification of Radionuclides and Development of Initial Radionuclide Inventory	Although the core inventory contains hundreds of different isotopes, only a limited subset of isotopes is explicitly modeled. This is not expected to be a significant source of uncertainty because the nuclides have been selected via a systematic process focused on identifying nuclides expected to be important to risk.
	Uncertainties in core inventory modeling from ORIGEN/SCALE propagate forward into core inventory estimation. This is not expected to be a significant source of uncertainty because the core inventory is not expected to be significantly different from that modeled, given the assumptions regarding burnup and time in cycle.
	The choice of the POS used to model the decay and ingrowth of radioactivity following shutdown for each release category is a source of uncertainty. For example, there is a rapid decay of short-lived radioactivity following shutdown. This could be significant for the estimation of early-phase exposures that depend upon short-lived radioactivity for accidents occurring relatively soon after shutdown.

Table 3-12 Uncertainties Related to Radionuclide Release Characterization (cont.)

3.1.2.3 Identification of Radionuclides and Development of Initial Radionuclide Inventory (cont.)	Uncertainties are introduced when estimating inventories of release categories that can occur either before or after refueling. For release categories that can occur either before or after refueling, the inventory available for release can be either more or less than that modeled here.
3.1.2.4 Chemical Class Assignments	Binning of elements into chemical classes is a source of uncertainty, as the chemical and physical form of each isotope may differ from the characteristics of the chemical class. This could be a significant source of uncertainty if the characteristics of transport or dosimetric characteristics of isotopes with multiple chemical forms vary significantly.
3.1.2.5 Aerosol Characteristics	The distribution of aerosol sizes may change over the course of the release but must be represented as a single value for all plume segments. This is not expected to be a significant source of uncertainty because later releases are expected to have a relatively stable aerosol size distribution. Releases that include both a relatively large early and late component may exhibit more significant differences in the evolution of the aerosol size distribution.
	Aerosol transformations that may alter the size distribution (e.g., agglomeration/accumulation/ deposition, iodine chemical form transformations) during transport in the environment are not explicitly treated in the modeling. This could be a significant source of uncertainty at long distances for early release with aerosol size distributions skewed toward the smaller end or conversion of iodine into less reactive forms.
	Uncertainty is introduced by the segmentation of a continuous aerosol size distribution into discrete bins. This is not expected to be a significant source of uncertainty because a reasonably large number of bins are defined, such that no single bin contains most of the release.
3.1.2.6 Plume Release Path Characterization	The exact location of releases associated with structural failure is unknown. It is expected that the impact of this uncertainty would be limited to the near field before significant vertical mixing occurs, as mixing within the boundary layer would eventually reduce the sensitivity of model results to alternate release heights (provided that significant depletion does not occur before the plume is fully mixed). The net effect of this uncertainty is related to plume rise effects, which have been examined in past SAMA analyses as a sensitivity. This could be a significant source of uncertainty for near-field effects, where ground-level concentrations could be sensitive to the plume size and height, but is not expected to be significant further downwind once the plume has grown in the vertical and crosswind directions.
	The crosswind building dimensions will vary depending upon the wind direction, which is not explicitly modeled.

Table 3-12 Uncertainties Related to Radionuclide Release Characterization (cont.)

3.1.2.7 Plume Segment Definitions	Uncertainty is introduced by the segmentation of a continuous release into discrete plume segments. This is not expected to be a major source of uncertainty, as these plume segments are generally divided into intervals consistent with the meteorological observation interval. Only very small releases are characterized by long plume segments.

Table 3-13 Potential Sensitivity Analyses to Address Uncertainties Related to Radionuclide Release Characterization

Analysis	Objective	MACCS Parameters to be Varied	Expected Results	Implementation Method
RE_1	Examine the impact of using a larger subset of radionuclides	Alternate isotope lists (i.e., from earlier studies or developed to include a wider set of nuclides), coupled with the more expansive set of dose factors available in the newer dose coefficient libraries	Small changes to estimated doses, particularly for long-term dose contributors	Alternate input decks
RE_2a	Examine effect of time of accident relative to time since shutdown	Adjust PDELAY and DLTSHL to vary accident initiation times relative to base values given in Table 3-4	Early-phase exposures may be affected for sequences occurring relatively soon after shutdown. Less significant for consequences dependent on longer-lived radionuclides such as Cs-137 and Cs-134.	Alternate input decks
RE_2b	Examine effect of time of accident relative to refueling cycle	Modify CORSCA to scale pre- or post-refueling inventories	Consequences expected to vary with burnup	Cyclic file set
RE_3	Propagation of uncertainty from Level 2 PRA (i.e., of uncertainty introduced by use of only a subset of available source terms)	All candidate source terms – all other MACCS parameters set to reference/base-case values	Conditional mean value of integrated risk not expected to vary significantly with source terms selected	Alternate input decks
RE_4	Propagation of key uncertainty from Level 2 PRA (i.e., accident truncation time)	Alternate source terms representing release truncation at earlier time(s)	Most consequences expected to be reduced with truncated source terms – consequences affected by warning time may be unaffected or less affected	Alternate input decks

Table 3-13 Potential Sensitivity Analyses to Address Uncertainties Related to Radionuclide Release Characterization (cont.)

Analysis	Objective	MACCS Parameters to be Varied	Expected Results	Implementation Method
RE_5	Examine how results change depending upon the number of aerosol size bins	Use of a single aerosol deposition velocity bin representing a net effective deposition velocity	Changes in the deposition behavior with distance – consequences may be higher or lower depending on figure of merit and distance range under consideration	Alternate input deck
RE_6	Examine importance of building wake effects associated with the release location	Effect could be examined by performing sensitivity analyses to vary initial plume size, building dimensions, and release height	It is expected that the impact of this uncertainty would be limited to the near field when the plume dimensions are comparable to the size of the building wake.	Cyclic file sets
RE_7	Examine impact of plume discretization timestep	Use of alternate (coarser or finer) plume segment intervals to examine how results may change	Staff experience with limited sensitivity analyses to evaluate the effect of plume segmentation suggest that this is probably only important for estimating early fatality risks from large releases.	Alternate input deck

3.2 Meteorological Data (ME)

3.2.1 Assumptions and Known Limitations

The following assumptions and limitations are reproduced from NRC (2022a):

- Hourly data for a single year is used for the site (8,760 data points for each year). The variability within a single year of weather data (intra-annual variability) is assumed to be sufficient to capture the variability across multiple years of weather data (i.e., inter-annual variability).

- Missing data is bridged over using hourly records before and after by employing "Procedures for Substituting Values for Missing National Weather Service Meteorological Data for Use in Regulatory Air Quality Models" (Atkinson and Lee, 1992), consistent with the method used in SOARCA.

- Atmospheric stability categories are classified using vertical temperature difference, consistent with SOARCA. This is assumed to be an adequate representation of atmospheric stability.

- Consistent with WASH-1400, depletion by rainfall using boundary weather settings should not be implemented closer than distances of about 500 miles, consistent with an atmospheric aerosol residence time of several days. Since the project is not reporting results at greater than 100 miles, boundary weather is therefore not modeled.

- The use of the simple flat terrain model assumed in MACCS is considered reasonable for this site, because of the limited topographic relief.

- The use of the 10-meter elevation wind speed as measured at the site is assumed to adequately represent wind speeds at higher elevations or longer distances from the site.

The following supplemental assumption is included as part of the LPSD analysis:

- It is assumed that the likelihood of an initiating event during LPSD operations is uniform throughout the year, that is, there is no seasonable dependence of LPSD operations. Therefore, it is assumed that sampling from a full year's worth of weather data is representative of the meteorological conditions that would occur over the course of releases initiated during LPSD conditions.

3.2.2 Technical Discussion

This section is included to maintain section numbering consistent with NRC (2022a). No changes in the selection and processing of meteorological data were made as part of the LPSD analysis.

3.2.3 MACCS Meteorological Input Parameter Summary

The summary of the MACCS input parameters related to meteorological data provided in Table 3-14 is adapted from Table 3.2-12 of NRC (2022a).

Table 3-14 Summary of MACCS Input Parameters Related to Meteorological Data

Variable	Description	Value	Source
MET file	Site Meteorological File	[SITE]1998LHt R2.inp	NRC (2022a), Section 3.2.2.2
MAXHGT	Flag for Mixing Height	DAY_AND_NIGHT	
LATITU	Latitude of Power Plant	33°08'30" N	
LONGIT	Longitude of Power Plant	81°45'44" W	
IRSEED	Seed for Random Number Generator	79	NRC (2022a), Section 3.2.2.3
METCOD	Meteorological Sampling Option Code	2	
NSMPLS	Number of Meteorological Samples per Bin or Day	0	
NRINTN	Number of Rain Intensity Breakpoints	2	
NRNINT	Number of Rain Distance Intervals	6	
NSBINS	Number of Weather Bins to Sample	34	
RNDSTS	Endpoints of Rain Distance Intervals (mi)	2,5,10,20,30,50	
RNRATE	Rain Intensity Breakpoints for Weather Binning (mm/hr)	2.5, 7.6	
INWGHT	Number of Samples for Each Bin used for Nonuniform Bin Sampling	Table 3.2-10 of NRC (2022a) (Column marked "ALL")[1]	
LIMSPA	Last Interval for Measured Weather	35	
BNDMXH	Boundary Weather Mixing Layer Height (m)	890	NRC (2022a), Section 3.2.2.4
BNDWND	Boundary Wind Speed (m/sec)	2.3	
IBDSTB	Boundary Weather Stability Class Index	5	
BNDRAN	Boundary Weather Rain Rate (mm/hr)	0	

1. *If a sampled subset of weather data is desired, the recommended values are provided in Table 3.2-10 of NRC (2022a) in the column marked "SUBSET."*

3.2.4 Identification and Discussion of Uncertainties Related to Meteorological Data

The following identification and discussion of uncertainties is reproduced from NRC (2022a). The discussion was supplemented to note the potential for a seasonal dependence of refueling operations.

There are several sources of uncertainty in the calculation. These are listed in Table 3-15, which was generated by reviewing each subsection to identify and characterize the sources of uncertainty. Table 3-16 provides a list of potential candidate sensitivity analyses based on a subset of the uncertainties identified in Table 3-15. A candidate sensitivity analysis has only been identified for those uncertainties that are considered readily amenable to quantitative modeling using MACCS. In some cases, there may be no straightforward method to examine the impact of the uncertainty, and therefore no candidate sensitivity analysis is identified. For most of the identified sources of uncertainty related to meteorological data, the recommended approach would be benchmarking against alternate conceptual models rather than developing a sensitivity analysis using the MACCS code. Additional discussion of potential uncertainties, and approaches to evaluate them, are provided below.

Use of only a single year's worth of data in the analysis is a source of uncertainty. Based on preliminary analyses, it was determined that the relative occurrence of stable, low wind speed conditions may be a more significant meteorological condition than total rainfall for consideration in selection of a representative weather year. However, for most of the figures of merit examined in the analysis, the mean values did not appear to be particularly sensitive to different weather conditions, as discussed in Section 4. The use of the 1998 dataset is therefore still considered reasonable, but further work could be carried out to develop weather files for other years to evaluate the sensitivity of results to different meteorological datasets. Sensitivity analyses could be conducted using meteorological files based on site meteorological data representing other years (see Section 3.2 of NRC 2022 for the justification of the selection of the 1998 dataset) or from MACCS meteorological files developed for the nearby industrial site.

It should be noted that the current modeling approach uses the MACCS variable RISCAT (as discussed in Section 3.7) to allow inference of how sensitive the mean value of different types of consequences could be to different weather conditions, which may vary in relative frequency of occurrence from year to year. The insights from this could be used to search for particularly significant weather conditions in alternate years or other approaches to developing a meteorological dataset that may give rise to differences in meteorological conditions such as stability, wind speed, or precipitation conditions. For most consequence measures, the mean value does not appear to be highly sensitive to different weather conditions. In such cases, the low relative frequency of adverse weather conditions is expected to offset any increased consequence associated with adverse weather conditions, at least in relation to mean consequences over all weather conditions.

It is assumed that sampling from a full year's worth of weather data is representative of the meteorological conditions that would occur over the course of releases initiated during LPSD conditions. This is acknowledged as a potential source of uncertainty, because refueling operations may exhibit a seasonal dependence (e.g., they may be more likely during the spring and fall seasons). To the extent that weather patterns (such as wind-speed, wind direction, and atmospheric stability) vary systematically throughout the year, a strong seasonal dependence could impact results. Development of a sensitivity analysis to examine the seasonal dependence of results may yield useful insights to improve realism. However, this is considered beyond state of practice and has not been undertaken for this project.

Table 3-15 Uncertainties Related to Meteorological Data

3.2.2.1 Selection of Data	Use of observations from a single observation point will not capture spatial variability in the winds, turbulence, or precipitation (in both the lateral and vertical direction). This could be a significant source of uncertainty, depending upon the consequence measure, the distance from the site, the characteristics of the release, and the complexity of the windfield. The effect of this uncertainty could be evaluated using analyses of benchmark analyses against alternate codes that do capture such effects, such as were conducted in Molenkamp et al. (2004). The effect of the higher fidelity models resulted in a difference in averaged air concentration and ground deposition levels within a factor of approximately 2 out to distances of about 100 miles.
	Use of only 1 year of weather data introduces uncertainty due to inter-annual variability in weather. The effect of this is not expected to be a major source of uncertainty, as there is significant variability within a single year, and the effect of extreme weather (which is more likely to be observed with a longer period of record) on atmospheric dispersion generally tends to increase dispersion. The effect of this could be examined using sensitivity analyses with data sets derived from alternate years (provided that the hourly observations are available; use of daily values would be unable to capture diurnal variability). The effect could also be captured with sensitivity analyses using datasets from alternate locations (i.e., local airports, nearby industrial site, etc.), but the applicability of observations from more remote locations may not capture site-specific meteorological characteristics.
3.2.2.2 MACCS Meteorology Implementation	Use of observations from the 10-meter level to represent transport at all heights within the atmospheric boundary layer is a source of uncertainty, given that wind speed and wind direction change with height and that a vertical turbulence structure can develop at night with different stability conditions at different elevations. This could be a significant source of uncertainty. This could be partially examined by using a data set from a higher (60-meter) elevation point, or more preferably, using a model (such as HYSPLIT) that explicitly models the vertical structure of transport properties.
	Very low wind speeds, and the uncertainty in turbulent dispersion at low wind speeds, cannot be accurately measured and are approximated in MACCS by assuming that any wind speed less than 0.5 m/s is modeled as 0.5 m/s. This is not expected to be a significant source of uncertainty because calm conditions are relatively infrequent, and calm winds would increase the time available for evacuation of close-in populations before significant exposures would occur.

Table 3-15 Uncertainties Related to Meteorological Data (cont.)

3.2.2.2 MACCS Meteorology Implementation (continued)	The use of stability classes rather than more continuous representations of turbulent dispersion is a source of uncertainty, as is the method (i.e., lapse rate versus sigma-theta or other approaches to stability classification). This could be a significant source of uncertainty, particularly if alternate methods resulted in a significantly different picture of atmospheric stability than that used in the analysis. The effect of this uncertainty could be evaluated using benchmark analyses against alternate codes that do capture such effects, such as were conducted in Molenkamp et al. (2004). The effect of the higher fidelity models resulted in a difference in air averaged concentration and ground deposition levels within a factor of approximately 2 out to distances of about 100 miles.
	The averaging interval used to represent weather could mask variability at smaller temporal scales. The effect of this could be captured using sensitivity analyses based on 15-min averaging intervals for meteorological intervals, if such data were available. This is not expected to be a major source of uncertainty, as it is judged that hourly intervals are adequate to capture variability in the weather, particularly for prolonged releases.
	Missing meteorological data must be inferred by expert judgment, which is subject to uncertainty. It is not expected that this is a major source of uncertainty in estimates of mean consequences, as the data recovery for the selected year is quite high and the potential for the substitution process to introduce systematic or significant errors is expected to be low.
	Although the depth of the atmospheric boundary layer would vary on a daily and hourly basis, it is represented as seasonal morning (minimum) and evening (maximum) values that are not correlated with the hourly data. Likewise, the diurnal variation of the turbulence structure in the boundary layer is represented by a simplified approach with only a single mixing layer (i.e., the effect of a nighttime residual layer aloft above a stable ground-level layer is not explicitly modeled). This could represent a significant source of uncertainty. The effect of this uncertainty could be evaluated using analyses of benchmark analyses against alternate codes that do capture such effects, such as were conducted in Molenkamp et al. (2004). The effect of the higher fidelity models resulted in a difference in averaged air concentration and ground deposition levels within a factor of approximately 2 out to distances of about 100 miles.

Table 3-15 Uncertainties Related to Meteorological Data (cont.)

3.2.2.3 Weather Bin Sampling	Use of only a subset of weather trials can introduce uncertainty in the estimates of the annual statistics. The effect of this has been evaluated in previous studies and generally found to be small (e.g., 1–2 percent in the SOARCA Peach Bottom uncertainty analysis), but the effect of sampling for this analysis could be quantified using sensitivity analyses (i.e., using all available weather data, using multiple runs to generate different sets of weather sequences, etc.). The effect would be expected to be most significant for relatively high-consequence low-conditional-likelihood effects, such as early health effects, which are unlikely to be observed under most weather conditions. The current base-case model includes all available weather data for the selected year.
3.2.2.4 Boundary Weather	Use of boundary weather that differs from actual weather is unrealistic. Although boundary weather is not used in this analysis, the uncertainty introduced by the boundary weather approach could be examined using sensitivity analysis varying LIMSPA to examine whether boundary rainout adequately envelopes impacts beyond the measured weather interval.

Table 3-16 Potential Sensitivity Analyses to Address Uncertainties Related to Meteorological Data

Analysis	Objective	MACCS Parameters to be Varied	Expected Results	Implementation Method
ME_1	Determine influence of selected weather year by running different years of meteorological data	Weather file	Minor changes in most results. Potentially noticeable change for low frequency results characterized by high-dose thresholds (i.e., early injuries or fatalities).	Alternate input decks
ME_2	Determine influence of sampling only a subset of weather trials	INWGHT and/or METCOD/NSMPLS	Minor changes in most results; potentially larger changes in early health effect measures.	Cyclic file set (if varying INWGHT)

3.3 Atmospheric Transport and Dispersion (ATD)

3.3.1 Assumptions and Known Limitations

The following assumptions and limitations are reproduced from NRC (2022a):

- The MACCS straight-line Gaussian plume segment model with provisions for meander and surface roughness is assumed to adequately represent atmospheric transport and dispersion across the range of prospective weather conditions.

- After a plume segment is released, the plume segment is assumed to not change direction (i.e., straight-line), and therefore does not account for variations in wind direction, wind field, or topography. This is expected to provide results that are reasonable in an average, ensemble sense (in the sense that changes in wind direction during transport are assumed to be offsetting), but the results from any given weather trial may not be representative of that specific meteorological sequence.

- Site-specific physical plant characteristics (e.g., building dimensions and stack heights) are used to determine height of releases and building wake.

- Buoyant plume rise is modeled using a buoyancy flux estimated from the gas flow rate and density of the released gases.

- Building wake effects are estimated using a virtual source. The initial plume size is assumed to be characteristic of the building from which the plume is released.

- Multi-phased releases that use hourly plume segments are assumed to be adequate to account for temporal variations in meteorological conditions (such as wind direction).

- Dry deposition velocities are calculated depending on the aerosol sizes used by MELCOR. Geographic or temporal variations in deposition velocity (e.g., due to changes in wind speed or surface roughness) are not included.

- Wet deposition velocities were based on SOARCA values and are the same for all source terms and weather conditions.

- The exclusion area, which is an irregular polygon, was modeled as a circular area with a radius of 0.75 miles.

- Wet deposition is based on parameter estimates appropriate for liquid precipitation (rain) rather than frozen precipitation (snow/ice) or fog.

- Based on benchmarking exercises documented in NUREG/CR-6853 (Molenkamp et al. 2004), the use of the straight-line Gaussian plume model is assumed to reasonably represent atmospheric and ground deposition variations with distance to a range of 100 miles.

- The mixing layer serves as an impenetrable boundary and can be modeled by assuming complete reflection of the plume from the mixing layer height.

- There are no changes in aerosol properties (e.g., deposition velocity) after release.

No supplemental assumptions were identified as part of the LPSD analysis.

3.3.2 Technical Discussion

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.3.2.1 Wind Shift Treatment and Spatial Grid Definition

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.3.2.2 Building Wake Effects

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, the only change is the addition of MELCOR flowpaths used in the LPSD MELCOR model used to, for example, represent open hatches. Project staff used the dimensions of the structure from which the release is modeled to occur to initialize the plume dimensions, consistent with SOARCA practice. The initial plume dimensions are therefore a characteristic of the MELCOR flowpath from which the plume segment is released. The characteristics of each MELCOR flowpath are tabulated in Table 3-17. It may be noted that all flowpaths in a MELCOR model must be defined for processing by MelMACCS even if no flow passes through the flowpath. For the LPSD analysis, several flowpaths were defined but not used, as described in Table 2-77 of NRC (2025). For this reason, these flow paths are identified by shading in the cells in Table 3-17. For reference, the flowpaths used for each source term used to represent a release category are provided in Table 3-18.

Table 3-17 Release Path Parameters for Dispersion Modeling

Description	MELCOR Flowpath	Release Height (m) PLHITE	Building Height (m) BUILDH	$\sigma_{y,init}$ (m) SIGYINIT	$\sigma_{z,init}$ (m) SIGZINIT
SG 1 SRV tailpipe	372	13	55	10.4	25.9
SG 1 SRV tailpipe	373	13	55	10.4	25.9
SG 1 SRV tailpipe	374	13	55	10.4	25.9
SG 1 SRV tailpipe	375	13	55	10.4	25.9
SG 1 lowest setpoint SRV tailpipe	376	13	55	10.4	25.9
SG 1 ARV tailpipe	377	13	55	10.4	25.9
SG 1 PORV leakage	379	13	55	10.4	25.9
SG 2 SRV tailpipe	472	13	55	10.4	25.9
SG 2 SRV tailpipe	473	13	55	10.4	25.9
SG 2 SRV tailpipe	474	13	55	10.4	25.9
SG 2 SRV tailpipe	475	13	55	10.4	25.9
SG 2 lowest setpoint SRV tailpipe	476	13	55	10.4	25.9
SG 2 ARV tailpipe	477	13	55	10.4	25.9
SG 2 PORV leakage	479	13	55	10.4	25.9
SG 3 SRV tailpipe	572	13	55	10.4	25.9
SG 3 SRV tailpipe	573	13	55	10.4	25.9
SG 3 SRV tailpipe	574	13	55	10.4	25.9
SG 3 SRV tailpipe	575	13	55	10.4	25.9
SG 3 lowest setpoint SRV tailpipe	576	13	55	10.4	25.9
SG 3 ARV tailpipe	577	13	55	10.4	25.9
SG 3 PORV leakage	579	13	55	10.4	25.9
SG 4 SRV tailpipe	672	13	55	10.4	25.9
SG 4 SRV tailpipe	673	13	55	10.4	25.9
SG 4 SRV tailpipe	674	13	55	10.4	25.9
SG 4 SRV tailpipe	675	13	55	10.4	25.9
SG 4 lowest setpoint SRV tailpipe	676	13	55	10.4	25.9

Table 3-17 Release Path Parameters for Dispersion Modeling (cont.)

Description	MELCOR Flowpath	Release Height (m) PLHITE	Building Height (m) BUILDH	$\sigma_{y,init}$ (m) SIGYINIT	$\sigma_{z,init}$ (m) SIGZINIT
SR 4 ARV tailpipe	677	13	55	10.4	25.9
SG 4 PORV leakage	679	13	55	10.4	25.9
Piping penetration area filtration and exhaust system exhaust	27	55	55	10.4	25.9
Normal Containment Leakage	820	42	55	10.4	25.9
Normal Containment Leakage	821	25	55	10.4	25.9
Normal Containment Leakage	824	16	55	10.4	25.9
Containment Overpressure	841	0	55	10.4	25.9
Containment Overpressure	842	0	55	10.4	25.9
Tendon gallery access shafts (2 of 3)	844	0	14	8.7	6.6
Aux Building Overpressure	995	11	14	8.7	6.6
Normal Aux Building Leakage	997	0	14	8.7	6.6
Normal Aux Building Leakage	998	6	14	8.7	6.6
Fuel handling building ventilation intakes, exhausts, and leaks	910	21m	55	10.4	25.9
Fuel handling building ventilation intakes, exhausts, and leaks	920	21m	55	10.4	25.9
Fuel handling building ventilation intakes, exhausts, and leaks	930	21m	55	10.4	25.9
Fuel handling building ventilation intakes, exhausts, and leaks	940	10m	55	10.4	25.9
Fuel handing building sliding door	941	2m	55	10.4	25.9
Equipment hatch	9599	1m	55	10.4	25.9
Equipment hatch	9609	4m	55	10.4	25.9
Personnel hatch	9851	2m	55	10.4	25.9
Personnel hatch	9852	2m	55	10.4	25.9
RWST vent	1310	18m	55	10.4	25.9
Containment overpressure failure path	7824	0m	55	10.4	25.9

Table 3-18 Release Path Modeled, by Source Term

Release Category	Case	MELCOR Flowpaths
SD-ISLOCA	SD11.1	27, 820, 821, 824, 995 (dominant path), 997, 998
SD-CIF	SD03	820, 821, 824, 842 (dominant path), 998
SD-COPEN-RCSINTACT	SD07	820, 821, 824, 9599, 9609 (dominant path), 998
SD-COPEN-RCSVENT	SD13	27, 820, 821, 824, 9599, 9609 (dominant path)
SD-COPEN-HEADOFF	SD05	820, 821, 824, 9599, 9609 (dominant path), 998
SD-ECF	SD01.2	27, 820, 821, 824, 844 (dominant path)
SD-CF-BEFORE-CD	SD09	820, 821, 824, 844 (dominant path), 997, 998,
SD-ICF-BURN	SD01.8	27, 820, 821, 824, 844 (dominant path)
SD-LCF	SD01	27, 820 (dominant path), 821, 824
SD-BMT	SD08.2	27, 820 (dominant path), 821, 824
SD-NOCF	SD12	27, 820 (dominant path), 821, 824

Source: adapted from Table 2-76 of NRC (2025)

3.3.2.3 Plume Rise

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.3.2.4 Surface Roughness

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.3.2.5 Dispersion/Turbulence Parameterizations

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.3.2.6 Deposition Modeling

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.3.3 MACCS Atmospheric Transport and Deposition Input Parameter Summary

The summary of the MACCS input parameters related to atmospheric transport and deposition provided in Table 3-19 is adapted from Table 3.3-8 of NRC (2022a).

Table 3-19 Summary of MACCS Input Parameters Related to Atmospheric Transport and Deposition

Variable	Description	Value	Source
IPLUME	Plume Model Dispersion Code	3	Section 3.3.2.1 of NRC (2022a)
OVRRID	Wind Rose Probability Override	.FALSE.	
NUMCOR	Number of Compass Sectors in the Grid	64	
NUMRAD	Number of Radial Spatial Intervals	35	
SPAEND	Radial distances for grid boundaries (km)	Table 3.3-1 of NRC (2022a)	
SIGYINIT	Initial Sigma-y (m)	Table 3-17	Section 3.3.2.2
SIGZINIT	Initial Sigma-z (m)		
BUILDH	Building Height (m)	Table 3-17	Section 3.3.2.3 of NRC (2022a)
BRGSMD	Briggs Model Flag	IMPROVED	
PLMMOD	Flag for Plume Rise Input Option	DENSITY	
SCLCRW	Scaling Factor for Critical Wind Speed	1	
SCLADP	Scaling Factor for A-D Plume Rise	1	
SCLEFP	Scaling Factor for E-F Plume Rise	1	
DISPMD	Dispersion Model Flag	LRTIME	Section 3.3.2.5 of NRC (2022a)
CYSIGA	Linear Coefficient for sigma-y		
	Stability Class A	0.7507	
	Stability Class B	0.7507	
	Stability Class C	0.4063	
	Stability Class D	0.2779	
	Stability Class E	0.2158	
	Stability Class F	0.2158	
CYSIGB	Exponential Term for sigma-y		
	Stability Class A	0.866	
	Stability Class B	0.866	
	Stability Class C	0.865	
	Stability Class D	0.881	
	Stability Class E	0.866	
	Stability Class F	0.866	
CZSIGA	Linear Coefficient for sigma-z		
	Stability Class A	0.0361	
	Stability Class B	0.0361	
	Stability Class C	0.2036	
	Stability Class D	0.2636	
	Stability Class E	0.2463	
	Stability Class F	0.2463	

(Continued on next page)

Table 3-19 Summary of MACCS Input Parameters Related to Atmospheric Transport and Deposition (cont.)

Variable	Description	Value	Source
CZSIGB	Exponential Term for sigma-z		Section 3.3.2.5 of NRC (2022a)
	Stability Class A	1.277	
	Stability Class B	1.277	
	Stability Class C	0.859	
	Stability Class D	0.751	
	Stability Class E	0.619	
	Stability Class F	0.619	
YSCALE	Scale Factor for Horizontal Dispersion	1.0	
ZSCALE	Scale Factor for Vertical Dispersion	2.0	
CYDIST	Distance for switching to long-range dispersion model (m)	30,000	
CYCOEF	Coefficient for crosswind dispersion (m/s)	0.5	
MNDMOD	Plume Conditional Meander Model Flag	OFF	
DRYDEP	Dry Deposition Flag	Xe = .FALSE. Other groups = .TRUE.	Section 3.3.2.6 of NRC (2022a)
VDEPOS	Dry Deposition Velocities (m/sec)		
	Aerosol Bin 1	1.07E-03	
	Aerosol Bin 2	9.85E-04	
	Aerosol Bin 3	1.29E-03	
	Aerosol Bin 4	2.18E-03	
	Aerosol Bin 5	4.26E-03	
	Aerosol Bin 6	8.71E-03	
	Aerosol Bin 7	1.68E-02	
	Aerosol Bin 8	2.75E-02	
	Aerosol Bin 9	3.41E-02	
	Aerosol Bin 10	5.15E-02	
WETDEP	Wet Deposition Flag	Xe = .FALSE. Other groups = .TRUE	
CWASH1	Linear Coefficient for Washout	1.89E-05	
CWASH2	Exponential Term for Washout	0.664	
IDEBUG	Debug Switch for Extra Debugging Print	0	
NUCOUT	Radionuclide Used in Dispersion Print	Cs-137	

3.3.4 Identification and Discussion of Uncertainties Related to Atmospheric Transport and Dispersion

The following identification and discussion of uncertainties is reproduced from NRC (2022a). No supplemental discussion was identified as necessary for the LPSD analysis.

There are several sources of uncertainty in the calculation. These are listed in Table 3-21 (adapted from Table 3.3-10 of NRC 2022a), which was generated by reviewing each subsection to identify and characterize the sources of uncertainty. Table 3-22 (adapted from Table 3.3-11 of NRC 2022a) provides a list of potential candidate sensitivity analyses based on a subset of the uncertainties identified in Table 3-21. A candidate sensitivity analysis has only been identified for those uncertainties that are considered readily amenable to quantitative modeling using MACCS. Additional discussion of potential uncertainties, and approaches to evaluate them, are provided below.

As discussed in Section 2.1.2 of Sprung et al. (1990), "selecting values for BUILDH and BUILDW may not be straightforward," because the degree of mixing would be affected by the level of ambient turbulence as well as the initial failure dimensions, which are uncertain. Furthermore, determining the height and, especially, the width of the building from which release occurs is not always straightforward. Because wake effects can persist for some distance downwind of a structure (EPA [1985] suggests 5 times the lesser of the width or height of the structure), a release from one part of the complex is likely to be affected by the wake generated by an adjacent structure. The reactor complex is comprised of a set of buildings and the heights and widths of the buildings in this complex vary. In addition, the complex is irregular in shape and the apparent width depends on the direction of the wind. In addition, there are alternate approaches to estimate the initial plume height and dimensions. As discussed in Section 5.10 of Chanin and Young (1998), an alternate approach to modeling building wake effects is provided in Jones (1983), which recommends that the initial plume dimensions be assigned simply as one-third of the height and width of the building, and the plume be released at an elevation of one-third of the building height. The initial plume dimensions (and equivalently, the location of the virtual source) are a source of uncertainty, particularly in the near field, that has not been assessed in this analysis. The effect of these parameters was evaluated for the Surry plant in NUREG/CR-6135 (Helton, et al., 1995b) (see Table 4.1), which correlated building width and height, with building height being assigned a range of 15–35 m and a best estimate of 25 m, and building width being assigned a range of 15–100 m with a best estimate of 60 m. However, neither of these parameters were identified as a dominant contributor to uncertainty. This effect was also evaluated in the site environmental report, where the evaluation of an increase in the assumed building length (and hence initial plume sigma-y) showed a minor decrease in dose very near the release point and no noticeable effect on the 50-mile population dose.

The treatment of plume rise has the potential to be a contributor to uncertainty. Credit for buoyant plume rise, which can allow dispersion to occur overhead before the plume reaches ground level, could reduce ground level atmospheric concentrations (and therefore doses) close to the point of release. However, this may also result in a reduced level of dry deposition, allowing higher atmospheric concentrations at longer distances downwind. The net effect could therefore be complex, with offsetting effects. The effects of uncertainty in release elevation, which would be analogous to the effects of plume rise, were assessed in the site environmental report, including sensitivities on the release elevation (with a change from ground level to the top of containment [modeled as 70 m in that analysis]). This change in release elevation

resulted in decreased deposition close in, but a slightly (10 percent) higher population dose within 50 miles, because of the relatively less depleted plume. A sensitivity on plume heat (resulting in buoyant plume rise) resulted in similar effects, suggesting that some MACCS results could be somewhat sensitive to the assumed plume release height characteristics.

The values used for the dispersion parameters have the potential to be a significant contributor to uncertainty. The variables YSCALE and ZSCALE, which are modifiers on the plume dimensions, were found to be a dominant contributor to uncertainty in Section 7 of NUREG/CR-6135 (Helton, et al., 1995b). Parameters related to transverse dispersion (CYSIGA and CZSIGA) were also found to be influential in SOARCA. NUREG-7161 (Bixler, et al., 2013) provides tables of parameter values for the dispersion power law for the full range of uncertainties. These distributions were revisited in SNL (2016) and, most recently, in Section 5.9.6 of SNL (2019). The rationale for adjusting these parameter distributions is explained in that document and is not reproduced here. The result was to provide a recommendation that the uncertainty in dispersion coefficients be represented by a log-triangular distribution for CYSIGA and CZSIGA, characterized by the parameters provided in Table 3-20.

Table 3-20 Log-Triangular Values for Dispersion Parameters CYSIGA and CZSIGA

Class	CYSIGA (m)			CZSIGA (m)		
	Lower Bound	Mode	Upper Bound	Lower Bound	Mode	Upper Bound
A/B	0.3002	0.7507	1.8768	0.0144	0.0361	0.0903
C	0.1625	0.4063	1.0158	0.0814	0.2036	0.509
D	0.1112	0.2779	0.6948	0.1054	0.2636	0.659
E/F	0.0863	0.2158	0.5395	0.0985	0.2463	0.6158

Source: adapted from Tables 5-17 and 5-18 of SNL (2019)

The degree to which these dispersion parameters should be adjusted for surface roughness (expected to impact vertical dispersion, i.e., implemented via ZSCALE) and plume meander (expected to impact transverse dispersion, i.e., implemented via YSCALE) is uncertain. Project staff recommends a range between 1 and 2.5 for ZSCALE to account for the potential uncertainties associated with surface roughness effects near the site. There is no specific project recommendation for quantitatively accounting for uncertainties in the treatment of plume meander, but alternate approaches (such as either the OLD or NEW meander model) available within MACCS could be used to investigate the sensitivity of results to different approaches.

Uncertainty in the treatment of both wet and dry deposition has the potential to be a significant source of uncertainty. Helton et al. (1995 a,b) found VDEPOS and (to a lesser extent) CWASH1 to be important parameters in the assessment of early and chronic exposure results. SNL (2016) found uncertainty in dry deposition velocity (VDEPOS), and to a lesser extent, wet deposition velocity (CWASH1), to be important sources of uncertainty for consequence results. Wet and dry deposition did not appear to be as significant for the analyses documented in SNL (2019). Like the distributions for the dispersion parameters CYSIGA and CZSIGA, the deposition parameters from NUREG/CR-7161 (Bixler et al. 2013) were revisited in SNL (2019). The distribution for VDEPOS derived in Section 5.9.2 of SNL (2019) was site-specific and is therefore not reproduced here. However, the general approach was to derive a distribution that was not as wide as those provided in NUREG-7161 by assuming that VDEPOS can be

characterized by a triangular distribution with a mode equal to the median value estimate, and the lower and upper bounds chosen to be the mode divided and multiplied by the square root of 10, respectively. As discussed in Section 5.9.1 of SNL (2019), the distribution for CWASH1 was estimated in a simpler manner and was just estimated as a log-uniform distribution between 1.6×10^{-6} s^{-1} and 1.6×10^{-4} s^{-1}.

Table 3-21 Uncertainties Related to Atmospheric Transport and Dispersion

3.3.2.1 Wind Shift Treatment and Spatial Grid Definition	The resolution of the spatial grid results in the need to average across potential variability. The use of a polar grid means that grid elements become increasingly larger with distance from the source. This is not expected to be a significant source of uncertainty because the grid is defined with high resolution near the site.
3.3.2.2 Building Wake Effects	The effects of building wake on initial dispersion are complex and are not explicitly modeled and are instead modeled using a virtual source approach. Although wake effects would depend upon wind speed, wind direction, and turbulence, only a single value of the virtual source can be assigned for all realizations for a given source term. This is expected only to be significant at very close ranges, and given the low population near the site, is therefore not expected to be a significant contributor to uncertainty.
3.3.2.3 Plume Rise	The effect of plume rise was assessed as important in the NRC/CEC pilot study, but no further information was found on how it was addressed. The effect of this is expected to be most important for the estimate of early health effects, as vertical mixing would eventually overwhelm the effects of release height on ground-level concentration once the vertical plume dimensions were sufficiently large. The effect of this could be examined using sensitivity analysis on the MACCS variable SCLCRW.
3.3.2.4 Surface Roughness	Surface roughness is an approximation based on land cover. It varies spatially and could change over time due to variations in land use in the model domain. The effect of this could be examined by performing sensitivity analyses on ZSCALE and dry deposition velocity. Sensitivity analyses conducted as part of the SOARCA project (NUREG/CR-7110, Volume 1, and NUREG/CR-7009) indicate a modest impact on consequence results if surface roughness is varied on its own. However, considered in conjunction with dry deposition velocity, this impact could be greater (see Deposition Modeling discussion below).
3.3.2.5 Dispersion/ Turbulence Parameterizations	Multiple parameterizations of the dispersion coefficients exist for use with Gaussian models. These were the subject of elicitation in Harper et al. (1995), and distributions for these are developed in Bixler et al. (2013). In addition, as discussed in NRC (2022a), alternate parameters for the power-law representation of the dispersion coefficients have been identified in literature reviews. The effect of alternate dispersion parameters could lead to changes in the estimates of air concentration and ground deposition. This is expected to be a significant source of uncertainty.

Table 3-21 Uncertainties Related to Atmospheric Transport and Dispersion (cont.)

	Use of a Gaussian plume segment model does not capture the dispersion associated with changes in the windfield or the turbulent dispersion over time in the horizontal and vertical direction. This is conceptually similar to the uncertainty identified earlier related to the use of observational data from only a single weather station, which is an assumption used to derive Gaussian plume-type models. This could be a significant source of uncertainty. The effect of this uncertainty could be evaluated using analyses of benchmark analyses against alternate codes that do capture such effects, such as was conducted in Molenkamp et al (2004). The effect of the higher fidelity models resulted in a difference in air concentration and ground deposition levels within a factor of approximately 2 out to distances of about 100 miles.
	The Gaussian plume segment model does not address topographic or geographic effects on transport and dispersion. Local topographic effects include phenomena such as land/sea breeze, slope or valley winds, thermal internal boundary layers, flow over hills, etc. Because the terrain surrounding the site is relatively flat with gently rolling hills, these effects are not expected to be significant. It should be noted that the potential effect of the bluff overlooking the river on which the site sits, has not been explicitly evaluated. However, the land across the river in that direction is a controlled access industrial facility.
3.3.2.6 Deposition Modeling	Use of a single deposition velocity for all weather trials does not explicitly account for more recent approaches to deposition modeling (i.e., resistance layer models) that can address deposition as a function of wind speed, turbulence, chemical form, etc. Deposition velocities are expected to be a significant source of uncertainty. These effects are implicitly included in the elicitations documented in Harper et al. (1995), such that the abstraction documented in Bixler et al. (2013) does account for stability, wind speed, and surface roughness; however, a single representative value must be identified. The effect of this uncertainty could be evaluated using benchmark analyses against alternate codes that do capture such effects.
	Wet deposition models in MACCS use only a single coefficient and do not account for the effectiveness of precipitation scavenging associated with different particle sizes, chemical forms, precipitation types (i.e., rain versus snow, fog-water deposition, etc.), washout versus rainout, etc. The uncertainty in wet deposition models was evaluated in Harper et al. (1995) and distributions for use in MACCS have been developed in Bixler et al. (2013). Wet deposition could be a significant source of uncertainty.
	The form of deposition (i.e., wet versus dry) will affect both the initial distribution of deposited material (i.e., within soil column, on pavement, on roofs, into drains, etc.) and the rate at which it weathers. This affects both the initial dose from external radiation, as the distribution of materials will determine how much attenuation occurs between the deposited material and a human receptor, and the rate at which the material weathers, thereby reducing the dose rates. The effect of these factors is discussed in NUREG/CR-6526. This could be a significant source of uncertainty.

Table 3-22 Potential Sensitivity Analyses to Address Uncertainties Related to Atmospheric Transport and Dispersion

Analysis	Objective	MACCS parameters to be varied	Expected Results	Implementation Method
AT_1	Examine effect of building wake effects on initial dispersion	SIGYINIT, SIGZINIT recalculated using alternate structure dimensions or alternate estimation methods	Potential change in outputs characterized by threshold-type results sensitive to high doses at close distances; less impact expected where travel distance is much larger than virtual source distance	Cyclic File Set
AT_2	Examine influence of plume rise on near-field results by suppressing plume rise	SCLCRW	Limited plume rise expected to increase threshold-type results sensitive to high doses	Cyclic File Set
AT_3	Examine uncertainty associated with plume rise parameters	SCLADP, SCLEFP	Limited plume rise expected to increase threshold-type results sensitive to high doses	Cyclic File Set
AT_4	Examine uncertainty in dispersion model coefficients	CYSIGA, CYSIGB, CZSIGA, CZSIGB	Results could be higher or lower depending upon specific result. Increased crosswind dispersion could reduce centerline doses but increase the geographic extent of contamination. Increased vertical dispersion could increase ground-level concentration for elevated releases but decrease ground-level concentration for ground-level releases.	Cyclic File Set

Table 3-22 Potential Sensitivity Analyses to Address Uncertainties Related to Atmospheric Transport and Dispersion (cont.)

Analysis	Objective	MACCS parameters to be varied	Expected Results	Implementation Method
AT_5	Examine effect of differentiating stable weather categories E/F	CYSIGA, CYSIGB, CZSIGA, CZSIGB based on Tadmor-Gur power-law curves or use of dispersion lookup table based on alternate parameterizations	Potential increase in outputs sensitive to tails of weather distribution (e.g., early health effects)	Cyclic File Set or Alternate Input Decks
AT_6	Examine effect of surface roughness on vertical dispersion	ZSCALE	Increased vertical dispersion could increase ground-level concentration for elevated releases, but decrease ground-level concentration for ground-level releases	Cyclic File Set
AT_7	Increased or decreased dry deposition velocity	VDEPOS recalculated using alternate percentiles for deposition velocity from Table 3.3-4	Higher deposition projected to lead to higher impacts close in offset by lower impacts at further distances	Cyclic File Set
AT_8	Examine effect of surface roughness or wind speed on deposition velocity	VDEPOS recalculated using alternate surface roughness and wind speeds	Higher deposition projected to lead to higher impacts close in offset by lower impacts at further distances	Cyclic File Set
AT_9	Examine effect of uncertainties in wet deposition	CWASH1, CWASH2 recalculated using alternate particle sizes and/or percentiles	Higher deposition projected to lead to higher impacts close in offset by lower impacts at further distances	Cyclic File Set

3.4 Protective Action Parameters and Other Site Data (PA) and Economic Factors (EC)

3.4.1 Assumptions and Known Limitations

The following assumptions and limitations are reproduced from NRC (2022a):

- Site-specific population data is based on 2010 census data and extrapolated forward to the project base year of 2015. Individuals are assumed to be located at their place of residence as represented by the centroids of the census blocks used to develop population estimates.

- A current code limitation is that MACCS estimates the long-term population distribution based on the sum of the individual early-phase cohorts. Although early-phase cohorts may be assigned to specific geographic locations based on their daytime locations rather than their residential locations, these cohorts are treated as residential for purposes of estimating long-term effects, such as long-term exposure and economic costs.

- Land use data (land/water fraction, fraction of land devoted to farming, etc.) and land value data are based on information from the Bureau of Economic Analysis reflected in the databases supplied with SECPOP 4.3.0 and escalated to the project base year of 2015.

- The economic consequences considered are limited to those calculated in the MACCS code. Other costs, such as costs for replacement power, onsite cleanup, or costs of medical care, are not addressed in this analysis.

- The restricted access industrial facility staff are modeled as members of the public for purposes of estimating per-capita wealth; that is, the costs associated with contamination of the restricted access industrial facility grid elements will assume that the per-capita wealth is the same as that of members of the general public in the surrounding area. This ensures that economic costs associated with the contamination of the restricted access industrial facility will be computed. This approach captures significant costs for the area but may not fully capture the costs of interdicting the industrial complex.

- There is only one small private school within the emergency planning zone (EPZ), but there are many schools within 15 miles of the EPZ. For sequences with a General Emergency (GE) projected shortly after Site Area Emergency (SAE), these schools are modeled as evacuating upon an SAE to facilitate use of the school facilities as shelters for EPZ evacuees. For sequences with longer delays between an SAE and GE, it is assumed that schools will be dismissed normally prior to a GE and would not be reopened, and no separate school population is therefore modeled for these sequences.

- Geographically specific per-capita daily costs for meals and lodging are estimated using published Federal per-diem rates for the nearest large metropolitan area.

- Estimates for per-capita wealth are adjusted using an inflation factor based on Bureau of Labor and Statistics (BLS) consumer price index (CPI) estimates.

- The protective actions assumed to be taken in the analysis include sheltering followed by evacuation, temporary or permanent relocation of individuals from areas of high projected doses, food and water interdiction, and decontamination.

- Dose projections are assumed to be available to support protective action decisions.

- MACCS evaluates the need for protective actions based on the results of dose calculations that credit shielding factors. This is a code limitation that is expected to be mildly conservative with respect to doses and health effects, because it will result in a lesser extent of protective actions than may otherwise be taken.

- It is assumed that the initiating events do not cause damage at the nearby industrial facility that would require competing offsite response resources.

- Evacuation modeling considers staged evacuations and uses site-specific evacuation time estimates (ETEs). Protective actions are assumed to be expanded beyond the EPZ based on dose projections and Environmental Protection Agency (EPA) protective action guidelines (PAGs). This is consistent with the site protective action recommendation (PAR) procedure, which includes steps for determining guidance for PARs beyond the EPZ. For sequences with expanded protective actions, a mandatory evacuation order of the population within either 10–15 or 10–20 miles is assumed to occur after the decision to evacuate the EPZ.

- The current MACCS approach to evacuation modeling does not account for changes in evacuation timing associated with seasonal or diurnal variability. The ETEs are based on the timings for a normal winter workday. This will include schools in session and employees at work. A winter workday was selected for the response scenarios because it presents several challenges to emergency-response implementation, including evacuating while residents are at work and mobilizing buses to evacuate schoolchildren.

- It is assumed that all conditions involving a GE will result in an order to evacuate the full 10-mile EPZ, rather than a shorter 2- or 5-mile radius.

- For purposes of determining when evacuation may be expanded beyond the EPZ, failure or bypass of the containment leading to a large release is assumed to be identified no later than 1 hour after failure.

- For estimating early-phase relocation times, the time needed to identify areas subject to evacuation following plume arrival is assumed to be 4 hours, since field survey teams would be dispatched early in the event and would be guided by dose projection and meteorological information to facilitate rapid identification of hotspots.

- Early-phase relocation applies only to non-evacuating cohorts. Because only a single non-evacuating cohort (comprising individuals inside and outside the evacuation zone) is modeled, a single early-phase relocation time is assumed to be applicable both to individuals within the official evacuation zone, as well as individuals outside the official evacuation zone.

- A shadow evacuation for those that are not directed to evacuate, but are likely to evacuate anyway, is included. The shadow evacuation zone, in which 20 percent of the

general public is assumed to evacuate, is modeled as extending five miles beyond the evacuation zone. Any shadow evacuation is assumed to occur in a circular fashion, even if the general public were directed to evacuate following a keyhole concept.

- The dose criterion for the required decontamination after a severe accident is uncertain. No long-term land cleanup goal or level currently exists. The current state of practice is to model decontamination to the level of meeting the habitability criteria as defined by the intermediate-phase PAGs. The use of the EPA intermediate-phase PAGs (2 rem in the year of the accident and 500 mrem in subsequent years) is assumed as a surrogate for decisions on cleanup and reoccupation.

- Food and land interdiction and population relocation are modeled based on projected dose levels that are inferred based on EPA and Food and Drug Administration (FDA) guidance. Areas with projected food doses above these levels are assumed to be interdicted.

- Decontamination is assumed to be complete within 1 year after the end of the intermediate phase (i.e., all decontamination is assumed to be completed within 2 years after the accident occurs).

- The MACCS cost model is assumed to adequately estimate the offsite costs arising from a reactor accident.

The following supplemental assumptions are included as part of the LPSD analysis:

- As discussed in Section 2.5.2 of NRC (2025), because there is no GE criterion equivalent to the prolonged loss of all offsite and all onsite AC power criterion that applies during at-power operations, there is considerable uncertainty in the timing of GE declaration for station blackouts during shutdown. It is assumed that a GE is declared by Emergency Director discretion for these scenarios.

- For source terms with a long period of low-level releases prior to the onset of a significant release, a dose projection period of ten days is used for early-phase relocation. This assumption is needed because the early-phase relocation is based on the dose projected over a period beginning with the arrival of the first plume segment. If doses below the relocation criteria were not received in this period, relocation would not be triggered in MACCS even if later releases were sufficient to trigger relocation based on PAG criteria.

- Refueling outages are characterized by a large, close-in work force to support the outage. However, it is assumed that this workforce would be promptly evacuated given a severe accident. To avoid skewing population-dependent results by including a large but temporary cohort with limited or no potential exposure, these workers are not modeled.

3.4.2 Technical Discussion

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.4.2.1 Site Demographic Characteristics (Site File Development)

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.4.2.2 Characterization of Exposure Pathways

3.4.2.2.1 Off-Centerline Correction Factors

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.4.2.2.2 Shielding and Protection Factors

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.4.2.2.3 Weathering and Resuspension Factors

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.4.2.2.4 Food Ingestion Pathways

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.4.2.2.5 Water Ingestion Pathways

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.4.2.2.6 Phase Durations, Exposure Periods, and Commitment Periods

The methodology for estimating phase durations is the same as that employed in the reactor at-power analysis (NRC 2022a) and is not repeated here. The value of 10 days for the emergency phase (ENDEMP) and 50 years for the long-term exposure period (EXPTIM) used in the at-power analyses is also used in the LPSD analysis. However, the methodology described in NRC (2022a) uses a source-term-specific value for the duration of the intermediate phase (DUR_INTPHAS) based on the size of the intermediate-phase affected population, Source-term-specific values were also developed for the LPSD analysis. Consistent with the at-power model, the duration of the intermediate phase (DUR_INTPHAS) was established as follows:

- No offsite contamination – no intermediate phase necessary
- Limited offsite contamination, where small areas (e.g., acres) of farmland or uninhabited land are contaminated – 3 months, as described in Jones et al. (2015). This was defined in terms of magnitude of affected population, where the cutoff population was taken as 100 persons.

- Moderate offsite contamination, where small areas (e.g., hundreds of acres) of farmland or low-density populated areas are contaminated – 6 months, as described in Jones et al. (2015). This was defined in terms of magnitude of affected population, where the cutoff population was taken as 1000 persons.

- Extensive offsite contamination (e.g., square miles) of populated land requiring interactions with many different stakeholders – 12 months, as described in Jones et al. (2015). This was defined in terms of magnitude of affected population, where the cutoff population was taken as greater than 1000 persons.

The resulting values are provided in Table 3-23.

Table 3-23 Sequence-Specific Intermediate-Phase Durations

Case	Release Category	DUR_INTPHAS (months)
SD11-1	SD-ISLOCA	12
SD03	SD-CIF	12
SD07	SD-COPEN-RCSINTACT	12
SD13	SD-COPEN-RCSVENT	12
SD05	SD-COPEN-HEADOFF	12
SD01-2	SD-ECF	12
SD09	SD-CF-Before-CD	12
SD01-8	SD-ICF-BURN	12
SD01	SD-LCF	3
SD08-2	SD-BMT	0
SD12	SD-NOCF	0

3.4.2.3 Evacuation, Sheltering, and KI Administration

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.4.2.3.1 Definition of Evacuation Zones and Network

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.4.2.3.2 Evacuation timing and speeds

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.4.2.3.3 Adjustment of Model Templates for Individual Source Terms

The methodology for adjusting evacuation models is the same as that employed in the reactor at-power analysis (NRC 2022a) and is not repeated here. In particular, the development of emergency response models (summarized in Table 3-24) and evacuation delay and speed

templates (summarized in Table 3-25) are the same as in the at-power internal events model. However, because the timing of GE declarations, and the timing of conditions leading to expansion of the evacuation beyond the EPZ are source-term-specific, the values for the delay to shelter after accident initiation[6] (DLTSHL) for each cohort are source-term-specific. These values were developed for the LPSD analysis using the methodology developed for the at-power internal events model. The EP model assignments and notification times are documented in Table 3-26. The resulting DLTSHL values are provided in Table 3-27, Table 3-28, and Table 3-29.

Table 3-24 Identification of Base-Case Emergency-Response Models

EP Model	Description
1	Evacuation of full EPZ (~10-mile radius). No further evacuation orders beyond 10 miles. School cohorts in the 10–15-mile region are not included.
2, 2S	Evacuation out to 15-mile radius. Depending upon the timing of the event, a separate school cohort may or may not be included.
3, 3S	Evacuation out to 20-mile radius. Depending upon the timing of the event, a separate school cohort may or may not be included.

Source: reproduced from Table 3.4-13 of NRC (2022a)

[6] Recall that, as in the reactor at-power internal events model, the delay to declaration of a GE and the time between the GE declaration and the notification of the offsite public is added into the delay to shelter value rather than being defined via the OALARM parameter.

Table 3-25 Emergency-Response Template

#	Short Name	Description	EVAKEY	Delay to Shelter (DLTSHL)	Delay to Evac (DLTEVA)	DURBEG (hr)	DURMID (hr)	ESPEED1 (early) (mph)	ESPEED2 (mid) (mph)
1	1GP1	0–10-mile general public, first 30%	KEYHOLE	0.25[1]	0.25	0.25	0.25	25	25
2	1GP2	0–10-mile general public, second 30%	KEYHOLE	0.25[1]	0.50	0.25	0.25	25	25
3	1GP3	0–10-mile general public, third 30%	KEYHOLE	0.50[1]	1.00	0.17	0.17	25	25
4	1GPT	0–10-mile general public, final 10% (tail)	KEYHOLE	2.00[1]	1.00	0.17	0.17	25	25
5	IND	Industrial facility workers	CIRCULAR	0.00[1]	2.75	0.50	0.50	5	15
6	1GPS	10–15-mile general public shadow evacuees	CIRCULAR	1.00[1]	1.00	0.25	0.25	30	30
7	2GP1	10–15-mile general public, first 30%	KEYHOLE	0.5[3]	0.75	0.17	0.17	25	25
8	2GP2	10–15-mile general public, second 30%	KEYHOLE	1.5[3]	1.5	0.25	0.50	20	15
9	2GP3	10–15-mile general public, third 30%	KEYHOLE	3.5[3]	1.75	0.25	0.50	10	5
10	2GPT	10–15-mile general public, final 10% (tail)	KEYHOLE	4[3]	2	0.25	1.25	5	5
11	SCH	10–15-mile schools	CIRCULAR	0.50[2]	1.00	0.25	0.25	25	25
12	2GPS	15–20-mile general public shadow evacuees	CIRCULAR	1.00	1.00	0.25	0.25	20	20
13	3GP1	15–20-mile general public, first 30%	KEYHOLE	1.00[3]	2.00	0.25	0.50	20	10
14	3GP2	15–20-mile general public, second 30%	KEYHOLE	2.50[3]	2.50	0.50	0.50	10	10
15	3GP3	15–20-mile general public, third 30%	KEYHOLE	4.50[3]	2.50	0.25	1.50	10	5
16	3GPT	15–20-mile general public, final 10% (tail)	KEYHOLE	6.00[3]	2.75	2.00	0.25	5	10
17	3GPS	20–25-mile general public shadow evacuees	CIRCULAR	1.00[3]	1.00	0.25	0.50	20	20
18	NE	Non-evacuees	NONE	n/a	n/a	n/a	n/a	n/a	n/a

Source: reproduced from Table 3.4-14 of NRC (2022a)

1. DLTSHL is added to the EPZ notification time given in Table 3-26.

2. DLTSHL is added to the SAE declaration time given in Table 3-26.

3. DLTSHL is added to the expanded evacuation notification time given in Table 3-26.

Table 3-26 Case-Specific Declaration Times for Model Expansions

Source Term	Release Category	EP Model	SAE Declaration (hr)	GE Declaration (hr)	EPZ (0–10 mile) Declaration (hr)	Expanded Evacuation Notification Time (hr)
SD11-1	SD-ISLOCA	3	17	18	18.75	22.75
SD03	SD-CIF	3	26	33	33.75	126.75
SD07	SD-COPEN-RCSINTACT	3	10	15	15.75	16.75
SD13	SD-COPEN-RCSVENT	3	1	5	5.75	8.75
SD05	SD-COPEN-HEADOFF	3	6	48	48.75	101.75
SD01-2	**SD-ECF**	**3**	**11**	**11.5**	**12.25**	**25.75**
SD09	SD-CF-Before-CD	3	23	24	24.75	119.75
SD01-8	**SD-ICF-BURN**	**3**	**11**	**11.5**	**12.25**	**60.75**
SD01[1]	SD-LCF	1	11	11.5	12.25	*216*
SD08-2[1]	SD-BMT	1	20	28	28.75	*216*
SD12[1]	SD-NOCF	1	17	30	30.75	*216*

1. Expanded evacuation notification times are defined for these release categories but not used because EP Model 1 does not assign any population to evacuating cohorts beyond 10 miles.

Table 3-27 DLTSHL (hr) for EP Model 1 Cohorts

Release Category	Source Term	EP Model	0–10 mi Public 1st Group	0–10 mi Public 2nd Group	0–10 mi Public 3rd Group	0–10 mi Evacuation Tail	Industrial Facility Workers	10–15 mi Shadow
SD11-1	SD-ISLOCA	3	31	31	31.25	32.75	30.75	31.75
SD03	SD-CIF	3	175	175	175.25	176.75	174.75	175.75
SD07	SD-COPEN-RCSINTACT	3	28	28	28.25	29.75	27.75	28.75
SD13	SD-COPEN-RCSVENT	3	565	565	565.25	566.75	564.75	565.75
SD05	SD-COPEN-HEADOFF	3	190	190	190.25	191.75	189.75	190.75
SD01-2	SD-ECF	3	94.5	94.5	94.75	96.25	94.25	95.25
SD09	SD-CF-Before-CD	3	166	166	166.25	167.75	165.75	166.75
SD01-8	SD-ICF-BURN	3	94.5	94.5	94.75	96.25	94.25	95.25
SD01	SD-LCF	1	94.5	94.5	94.75	96.25	94.25	95.25
SD08-2	SD-BMT	1	34	34	34.25	35.75	33.75	34.75
SD12	SD-NOCF	1	538	538	538.25	539.75	537.75	538.75

Table 3-28 DLTSHL (hr) for Additional Cohorts for EP Model 2

Release Category	Source Term	EP Model	10-15 mi Public 1st Group	10-15 mi Public 2nd Group	10-15 mi Public 3rd Group	10-15 mi Evacuation Tail	10-15 mi Schools	15-20 mi Shadow
SD11-1	SD-ISLOCA	3	35.25	36.25	38.25	38.75	29.5	35.75
SD03	SD-CIF	3	268.25	269.25	271.25	271.75	167.5	268.75
SD07	SD-COPEN-RCSINTACT	3	29.25	30.25	32.25	32.75	22.5	29.75
SD13	SD-COPEN-RCSVENT	3	572.25	573.25	575.25	575.75	551.5	572.75
SD05	SD-COPEN-HEADOFF	3	243.25	244.25	246.25	246.75	147.5	243.75
SD01-2	SD-ECF	3	298.5	299.5	301.5	302	93.5	299
SD09	SD-CF-Before-CD	3	268.25	269.25	271.25	271.75	164.5	268.75
SD01-8	SD-ICF-BURN	3	112.25	113.25	115.25	115.75	93.5	112.75
SD01[1]	SD-LCF	1	298.5	299.5	301.5	302	93.5	299
SD08-2[1]	SD-BMT	1	221.5	222.5	224.5	225	25.5	222
SD12[1]	SD-NOCF	1	723.5	724.5	726.5	727	524.5	724

1. DLTSHL values are defined for these cohorts but are not used in the analysis because no population is assigned to these cohorts in EP Models 2 and 3.

Table 3-29 DLTSHL (hr) for Additional Cohorts for EP Model 3

Release Category	Source Term	EP Model	15-20 mi Public 1st Group	15-20 mi Public 2nd Group	15-20 mi Public 3rd Group	15-20 mi Evacuation Tail	20-25 mi Shadow
SD11-1	SD-ISLOCA	3	35.75	37.25	39.25	40.75	35.75
SD03	SD-CIF	3	268.75	270.25	272.25	273.75	268.75
SD07	SD-COPEN-RCSINTACT	3	29.75	31.25	33.25	34.75	29.75
SD13	SD-COPEN-RCSVENT	3	572.75	574.25	576.25	577.75	572.75
SD05	SD-COPEN-HEADOFF	3	243.75	245.25	247.25	248.75	243.75
SD01-2	SD-ECF	3	299	300.5	302.5	304	299
SD09	SD-CF-Before-CD	3	268.75	270.25	272.25	273.75	268.75
SD01-8	SD-ICF-BURN	3	112.75	114.25	116.25	117.75	112.75
SD01[1]	SD-LCF	1	299	300.5	302.5	304	299
SD08-2[1]	SD-BMT	1	222	223.5	225.5	227	222
SD12[1]	SD-NOCF	1	724	725.5	727.5	729	724

1. DLTSHL values are defined for these cohorts but are not used in the analysis because no population is assigned to these cohorts in EP Model 3.

3.4.2.3.4 Evacuation Costs

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

A summary of the parameters used to model KI administration, sheltering, and evacuation is provided in Table 3-30.

Table 3-30 KI, Sheltering, and Evacuation Parameters

MACCS Variable	Description	Value	Comment
KIMODL	Model Flag for KI Ingestion	NOKI	
EVATYP	Radial or network model flag	NETWORK	
KEYAVAIL	Indicates whether keyhole evacuation is used for possible evacuation	KEY_AVAIL	
EVAKEY	Evacuation algorithm	Table 3-25	Varies by cohort
KEYFORCST	Hours of forecast weather available	3	
NSECTR	Number of sectors in keyhole	13	
KEYDIS	Radius of circular area of keyhole	9	Ring 9 coincides with 5 miles
NUMEVA	Number of radial elements comprising the sheltering and evacuation region	25	Ring 25 coincides with 25 miles
LASMOV	Outermost spatial interval of the evacuation movement zone	28	Ring 28 coincides with 50 miles
TRAVELPNT	Boundary or Centerpoint	CENTERPOINT	
REFPNT	Reference time point for evac zone	ALARM	
DLTSHL	Delay to shelter	Table 3-27 Table 3-28 Table 3-29	Varies by sequence and cohort: All rings use same value
DLTEVA	Delay to evacuation	Table 3-26	Varies by cohort
DURBEG	Duration of the initial evac phase	Table 3-26	
DURMID	Duration of the middle evac phase	Table 3-26	
ESPEED	Travel speed of evacuees	Table 3-26	
ESPMUL	Speed multiplier during adverse weather	0.85	
ESPGRD_NET	Grid-dependent speed multiplier	Table A.3 of NRC (2022a)	
IDIREC	Destination direction of spatial elements	Table A.4 of NRC (2022a)	

3.4.2.4 Relocation and Interdiction Model

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.4.2.4.1 Early-Phase Relocation (EARLY)

For the LPSD analysis, the same methodology used for the at-power internal events analysis was used to estimate the time of hotspot and normal relocation. Early-phase relocation was based on the EPA early-phase PAG of 1–5 rem in 4 days, such that DOSHOT was set equal to 5 rem, DOSNRM was set equal to 1 rem, and DPPEMP was set equal to 4 days. This methodology based the relocation times (TIMHOT and TIMNRM) on the extent of the modeled evacuation zone (i.e., the EP model) and the resulting values are shown in Table 3-31.

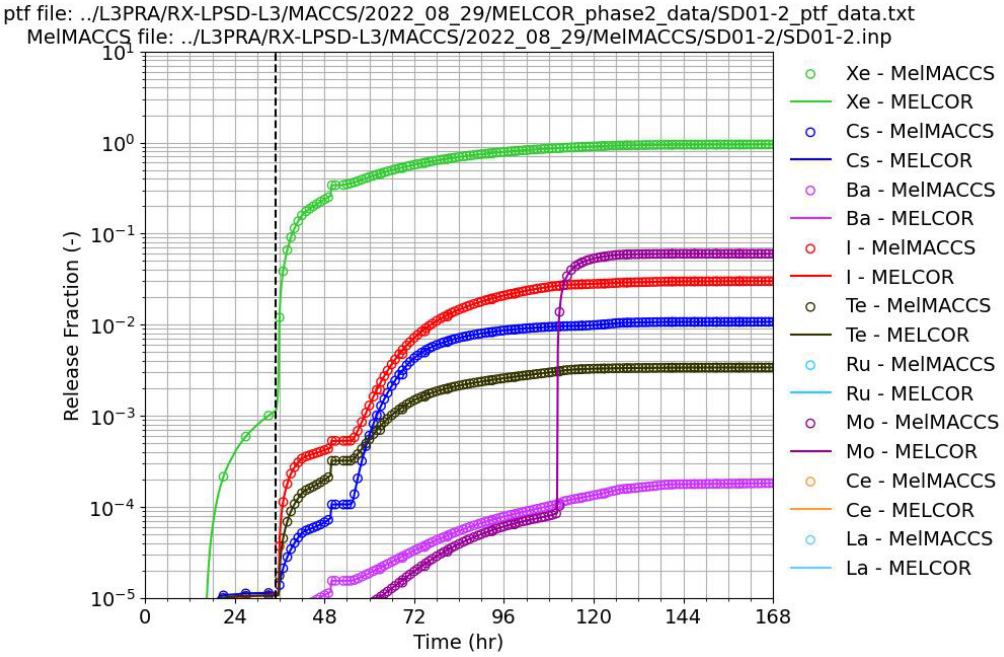
Table 3-31 Recommended Early-Phase Relocation Timing

EP Model	Evacuation Zone Radius (mi)	Assumed Identification Time (hr)	90th Percentile ETE	100th Percentile ETE	Hotspot Relocation Time (hr)	Normal Relocation Time (hr)
1	10	4	1.67	3.33	5.67	7.33
2/2S	15	4	6.00	7.50	10	11.5
3/3S	20	4	8.75	10.75	12.75	14.75
3/3S*	20	4	8.75	10.75	12.75	24

Source: reproduced from Table 3.4-18 of NRC (2022a)

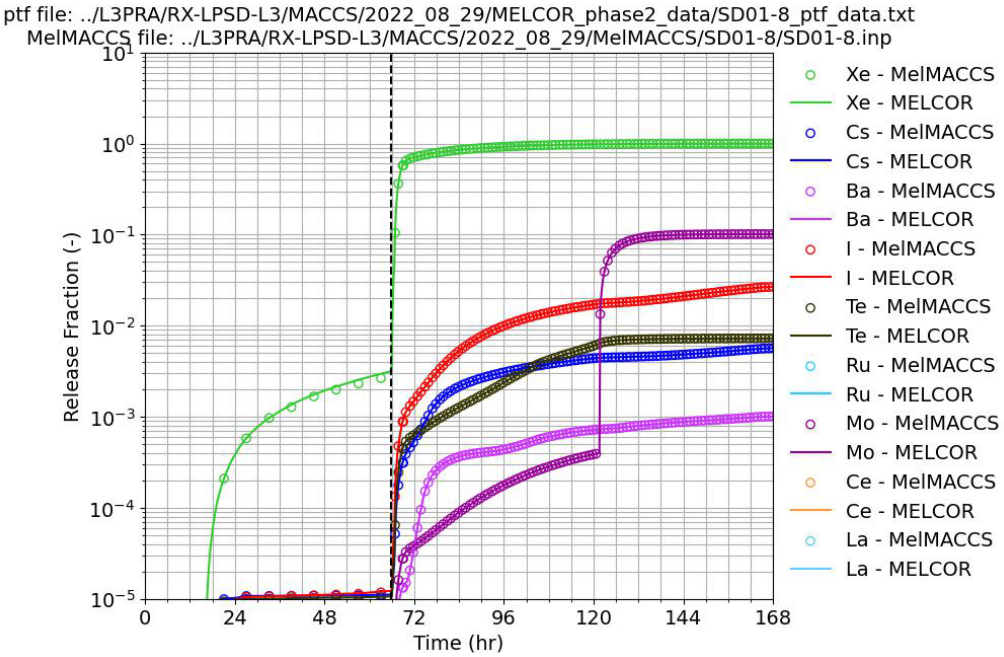
**Used for cases with more than 1,000 projected normal evacuation relocatees beyond the evacuation zone.*

Preliminary analyses revealed that for two source terms (SD01-2 and SD01-8, used to represent the SD-ECF and SD-ICF-BURN release categories, respectively), the model summarized in Table 3-31 resulted in a very limited extent of relocation and a correspondingly high dose to the non-evacuating cohort at short distances. It was determined that this arose because of a prolonged period of low-level releases prior to the onset of a large release. This is shown in Figure 3-5 and Figure 3-6 below, illustrating the time dependence of the release. Each vertical division in these figures represents a period of 6 hours. Because the MACCS early-phase relocation model is based on the dose accrued for a fixed period (DPPEMP) after arrival of the first plume segment, a prolonged initial period of low-level releases may not be sufficient to accumulate the dose needed to trigger the relocation model, even if a subsequent release is sufficient to reach the EPA PAG levels of 1–5 rem in 4 days. In these cases, no relocation will be projected, even if subsequent releases were sufficient to exceed PAG levels.



Note: The dashed line indicates the plume segment of maximum risk for use in MACCS calculations.

Figure 3-5 Comparison of MELCOR and MelMACCS Post-Processed Release Fraction Profiles for SD01-2 (ECF)



Note: The dashed line indicates the plume segment of maximum risk for use in MACCS calculations.

Figure 3-6 Comparison of MELCOR and MelMACCS Post-Processed Release Fraction Profiles for SD01-8 (ICF-BURN)

For these two source terms, the dose projection period was therefore extended to 10 days to be the same value as the duration of the emergency phase (ENDEMP) to ensure that doses of 1–5 rem accumulated over the emergency phase would trigger relocation. This approach is consistent with the earlier implementation of the early-phase relocation model in MACCS prior to the introduction of the DPPEMP variable. However, to avoid artificially truncating the potential dose by an early relocation prior to onset of a major release, the relocation times for these source terms were extended by adding in the elapsed time between the arrival of the first plume segment and the arrival of the maximum risk plume segment (shown in Figure 3-5 and Figure 3-6).The resulting hot spot and normal relocation times, as well as the dose protection periods, are given for each release category in Table 3-32.

Table 3-32 Early-Phase Relocation Parameters

Release Category	Modeling Case	EP Model	Hotspot Relocation Time (hr) (TIMHOT)	Normal Relocation Time (hr) (TIMNRM)	Dose Projection Period (days) (DPPEMP)
ISLOCA	SD11-1	3	12.75	24	4
CIF	SD03	3	12.75	24	4
COPEN-RCSINTACT	SD07	3	12.75	24	4
COPEN-RCSVENT	SD13	3	12.75	24	4
COPEN-HEADOFF	SD05	3	12.75	24	4
ECF	SD01-2	3	32.75	44	10
CF-Before-CD	SD09	3	12.75	24	4
ICF-BURN	SD01-8	3	63.5	74.75	10
LCF	SD01	1	5.67	7.33	4
BMT	SD08-2	1	5.67	7.33	4
NOCF	SD12	1	5.67	7.33	4

3.4.2.4.2 Intermediate-Phase Relocation and Recovery-Phase Interdiction (CHRONC)

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.4.2.4.3 Estimation of Relocation Costs

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.4.2.4.4 Estimation of Loss of Use Costs

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.4.2.5 Decontamination Model

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.4.3 MACCS Protective Action/Economic Cost Input Parameter Summary

A summary of the MACCS input parameters related to protective action parameters, site data, and economic factors is provided in Table 3-33.

Table 3-33 Summary of MACCS Input Parameters Related to Protective Action Parameters, Site Data, and Economic Factors

Variable	Description	Value	Source
ENDAT2	Control flag indicating only ATMOS and EARLY are to be run	.FALSE.	
WTNAME	Type of weighting for cohorts	SUMPOP	Sect. 3.4.2.1
POPFLG	Population distribution flag	FILE	
Site File	Name of site file	Table 3.4-5 of NRC (2022a)	
NUM_EVAC_SCEN	Number of cohorts	18	
NUMFIN	Number of fine grid subdivisions for early-phase dose projections	7	Sect. 3.4.2.2
ENDEMP	Emergency-phase duration	10 days	
DUR_INTPHAS	Intermediate-phase duration	Table 3-23	
EXPTIM	Recovery-phase exposure duration	50 years	
CSFACT (General Public)	Cloudshine shielding factor for general public cohorts	0.75/0.6/0.95 (NORM/SHLT/ EVAC)	
CSFACT (Schools/Industrial)	Cloudshine shielding factor for schools and industrial worker cohorts	0.31/0.31/0.95 (NORM/SHLT/ EVAC)	
PROTIN (General Public)	Inhalation protection factor for general public cohorts	Median from Table 3.4-7 of NRC (2022a)	
PROTIN (Schools/Industrial)	Inhalation protection factor for schools and industrial cohorts	0.33/0.33/0.98 (NORM/SHLT/ EVAC)	
SKPFAC (General Public)	Skin protection factor for general public cohorts	Median from Table 3.4-7 of NRC (2022a)	
SKPFAC (Schools/Industrial)	Skin protection factor for schools and industrial cohorts	0.33/0.33/0.98 (NORM/SHLT/ EVAC)	
GSHFAC (General Public)	Groundshine shielding factor for general public cohorts	Median from Table 3.4-6 of NRC (2022a)	

Table 3-33 Summary of MACCS Input Parameters Related to Protective Action Parameters, Site Data, and Economic Factors (cont.)

Variable	Description	Value	Source
GSHFAC (Schools/Industrial)	Groundshine shielding factor for schools and industrial cohorts	0.1/0.1/0.4 (NORM/SHLT/ EVAC)	Sect. 3.4.2.2
LPROTIN	Chronic inhalation protection factor	1	
LGSHFAC	Chronic groundshine shielding factor	0.22	
BRRATE	EARLY breathing rate	0.000219 m^3/s	
LBRRATE	CHRONC breathing rate	0.000219 m^3/s	
NGWTRM	Number of terms in groundshine weathering equation	2	
GWCOEF	CHRONC groundshine factors	0.5, 0.5	
TGWHLF	CHRONC groundshine half-lives (s)	1.6E7; 2.8E9	
RESCON	EARLY resuspension factor	Table 3.4-9 of NRC (2022a)	
RESHAF	EARLY resuspension half-life		
NRWTRM	CHRONC number of resuspension weathering terms	3	
RWCOEF	CHRONC resuspension factors	Table 3.4-9 of NRC (2022a)	
TRWHLF	CHRONC resuspension half-lives		
FDPATH	COMIDA2 versus MACCS Food Model Switch	NEW	
COMIDA File	Name of COMIDA file	comida2_FGR13GyEquivDCF.bin	
DOSEMILK	Max milk dose first year	0.0375 rem effective 0.375 rem thyroid	
DOSEOTHER	Max food dose first year	0.14 rem effective 1.4 rem thyroid	
DOSELONG	Max food dose subsequent years	0.14 rem effective 1.4 rem thyroid	
NUMWPI	Number of water ingestion radionuclides	4	
NAMWPI	Water ingestion radionuclides	Sr89, Sr90, Cs134, Cs137	
WSHFRI	Initial washoff fraction	0.01, 0.01, 0.005, 0.005	

Table 3-33 Summary of MACCS Input Parameters Related to Protective Action Parameters, Site Data, and Economic Factors (cont.)

Variable	Description	Value	Source
WSHRTA	Annual washoff rate	0.004, 0.004, 0.001, 0.001	Sect. 3.4.2.2
KIMODL	Model Flag for KI Ingestion	NOKI	Sect. 3.4.2.3
EVATYP	Radial or network model flag	NETWORK	
KEYAVAIL	Flag indicating availability of keyhole model	KEY_AVAIL	
EVAKEY	Evacuation algorithm	Table 3-25	
KEYFORCST	Hours of forecast weather available	3	
NSECTR	Number of sectors in keyhole	13	
KEYDIS	Number of rings in circular area of keyhole	9	
TRAVELPNT	Flag used to define the location of an evacuee	CENTERPOINT	
NUMEVA	Number of radial elements comprising the sheltering and evacuation region	25	
LASMOV	Outermost spatial interval of the evacuation movement zone	28	
REFPNT	Reference time point for evacuation zone	ALARM	
OALARM	Time after accident that offsite alarm is initiated (s)	0 (included in DLTSHL)	
DLTSHL	Delay to shelter	Table 3-27 Table 3-28 Table 3-29	
DLTEVA	Delay to evacuation	Table 3-25	
DURBEG	Duration of the initial evacuation phase	Table 3-25	
DURMID	Duration of the middle evacuation phase	Table 3-25	
ESPEED	Travel speed of evacuees	Table 3-25	
ESPMUL	Speed multiplier during adverse weather	0.85	
ESPGRD_NET	Grid-dependent speed multiplier	Table A.3 of NRC (2022a)	
IDIREC	Evacuation direction	Table A.4 of NRC (2022a)	

Table 3-33 Summary of MACCS Input Parameters Related to Protective Action Parameters, Site Data, and Economic Factors (cont.)

Variable	Description	Value	Source
CRIORG	Critical organ for EARLY relocation	L-ICRP60ED	Sect. 3.4.2.4
DOSHOT	Hotspot relocation dose threshold	5 rem	
DOSNRM	Normal relocation dose threshold	1 rem	
TIMHOT	Hotspot relocation action time	Table 3-32	
TIMNRM	Normal relocation action time	Table 3-32	
DPPEMP	Dose projection period for the emergency phase	Table 3-32	
CRTOCR	Critical organ for intermediate-phase relocation and recovery-phase interdiction	L-ICRP60ED	
DSCRTI	Intermediate-phase dose criterion	2 rem	
DPP_INTPHAS	Dose Projection Period for the Intermediate Phase (s)	3.15E7 (1 year)	
DSCRLT	Recovery-phase dose criterion	0.5 rem	
TMPACT	Recovery-phase dose projection period (s)	3.15E7 (1 year)	
EVACST	Daily compensation for evacuees and relocatees	$190	
RELCST	Daily compensation for intermediate-phase relocatees	$135	
POPCST	Per-capita removal cost for long-term interdiction	$8,344	
DPRATE	Depreciation rate for improvements	20%	
DSRATE	Rate of return on investment for property; discount rate for estimating current worth	6%	
VALWF	Farmland wealth per hectare	$8,415/hectare	
FRFIM	Farmland wealth improvements fraction	0.2	
VALWNF	Nonfarm wealth per person	$335,900/person	
FRNFIM	Nonfarm wealth improvements fraction	0.55	
LVLDEC	Number of decontamination Levels	3	Sect. 3.4.2.5
TIMDEC	Decontamination time	1 yr	
DSRFCT	Decontamination efficiency	3, 5, or 15	

Table 3-33 Summary of MACCS Input Parameters Related to Protective Action Parameters, Site Data, and Economic Factors (cont.)

Variable	Description	Value	Source
CDFRM	Decontamination cost, farmland	Table 3.4-21 of NRC (2022a)	Sect. 3.4.2.5
CDNFRM	Decontamination cost, nonfarm		
DLBCST	Decontamination labor cost	$79,380/year	
FRFDL	Labor decon. cost fraction, farmland	0.35	
FRNFDL	Labor decon. cost fraction, nonfarm	0.35	
TFWKF	Labor decon. time fraction, farmland	0.1	
TNFWKF	Labor decon. time fraction, nonfarm	0.1	

**Not applicable when using SUMPOP.*

3.4.4 Identification and Discussion of Uncertainties Related to Protective Actions Parameters, Site Data, and Economic Factors

The following identification and discussion of uncertainties is adapted from NRC (2022a). It has been supplemented to recognize the additional uncertainty associated with the timing of EAL declarations.

There are several sources of uncertainty related to protective actions parameters, site data, and economic factors in the calculation. These are listed in Table 3-34, which was generated by reviewing each subsection to identify and characterize the sources of uncertainty. Table 3-35 provides a list of potential candidate sensitivity analyses based on a subset of the uncertainties identified in Table 3-34. A candidate sensitivity analysis has only been identified for those uncertainties that are considered readily amenable to quantitative modeling using MACCS.

The significance of sources of uncertainty in site data and protective actions is expected to be a function of the characteristics of the source term being analyzed. Most of the source terms in the Level 3 PRA project are relatively delayed, such that protective actions effectively limit (or eliminate) doses in the early phase. For these source terms, exposures therefore tend to be dominated by long-term exposure to lightly contaminated areas after reoccupation. The significant sources of uncertainty are therefore expected to be those associated with the long-term exposure pathways. Since these doses are predominantly associated with groundshine, and the shielding factor is a linear multiplier on the groundshine dose, this shielding factor is expected to be a significant source of uncertainty. For the earlier release sequences in which protective actions may not be as effective in eliminating early exposures, shielding factors related to plume exposure, particularly the inhalation protection factor PROTIN, could become a significant contributor to uncertainty.

Likewise, evacuation delays (DLTSHL, DLTEVA) and speeds (ESPEED) could be a significant source of uncertainty for some release categories. KEYFORCST is like an evacuation delay in that it limits the onset of evacuation until a specified time before the wind is projected to shift. For these parameters, the significance of the uncertainty is believed to be a function of the timing of the release. Many of the releases modeled in the Level 3 PRA project have a sufficiently long warning time that the results may be relatively insensitive to even relatively large changes in the evacuation timing of the cohorts within 10 miles. The significance of the uncertainty in the evacuation parameters would increase to the extent that the releases overlap with the clearance of the evacuation zone. This effect would be most pronounced for early releases, such as bypass events. For intermediate and late containment failure sequences, which typically have a much longer warning time, the significance of uncertainties in evacuation parameters is expected to be much lower. In this analysis, hotspot and normal relocation times are not expected to be as significant for many sequences since evacuation is explicitly modeled out to a distance of up to 20 miles and doses are projected to be low (under PAG limits) beyond this distance. For some of the largest releases, under which PAG projections could be exceeded beyond 20 miles, hotspot and normal relocation times could be significant, because these populations are modeled as non-evacuating and therefore subject only to early-phase relocation. This effect can be seen in Tables 6-13 through 6-15 of SNL (2019), where relocation times are not a significant contributor to uncertainty within the 10-mile evacuation zone but are significant beyond the evacuation zone.

Similarly, there is considerable uncertainty associated with the timing of GE declarations for station blackout scenarios for the LPSD analysis. This is discussed in Section 3.1 and Table 3-3

of this document and in Section 2.5.2 of NRC (2025). During shutdown conditions, there is no GE criterion equivalent to the prolonged loss of all offsite and all onsite AC power criterion that applies during at-power operations. For the LPSD analysis it is therefore assumed that GE is declared via Emergency Director discretion (HG2) for such release categories. However, it should be noted that this would only be a significant source of uncertainty if the actual GE declaration were delayed for these release categories until the point that releases were imminent or were occurring (i.e., if it resulted in a warning time on the order of less than a few hours and did not provide sufficient time for evacuation of the EPZ). For three of these release categories (SD-CIF, SD-COPEN-HEADOFF, and SD-CF-Before-CD), the accident is initiated almost 6 days after shutdown and the GE declarations in Table 3-4 are projected to occur 2 or more days before the onset of core damage. Only a very delayed GE declaration would result in increased early-phase exposures from these release categories.

The suite of cost parameters has the potential to be significant sources of uncertainty in the estimation of economic impacts. Because MACCS also includes consideration of economic costs in long-term cleanup decisions (i.e., actions which would result in economic impacts greater than the value of the property being decontaminated will result in permanent interdiction rather than decontamination and reoccupation), very high projected recovery costs can also impact estimates of doses and health risks from long-term exposure. Because the total economic impact is comprised of several different cost categories, the overall results may not be highly sensitive to any single cost parameter. However, the lack of empirical data on the costs of recovery from a large-scale radiological incident suggests that there could be large uncertainties in economic costs. These costs are difficult to extrapolate from the limited real-world data from Chernobyl and Fukushima, due to the potential differences in recovery strategies and compensation structures that would be put in place in different countries. The use of input-output models, which are used to estimate the impact of disruptions to different sectors of an economy, may be a more suitable method for assessing economic impacts (at least in relation to impacts on GDP). Parameters that affect multiple cost categories are expected to demonstrate more model sensitivity and, therefore, would be expected to be more important contributors to uncertainty. Examples include the habitability criteria (DSCRLT and TMPACT), which would increase or decrease the extent of protective actions, and the length of the intermediate or recovery phases (DUR_INTPHAS and TIMDEC).

Table 3-34 Uncertainties Related to Protective Action Parameters, Site Data, and Economic Factors

PA/EC 3.4.2.1 Site Demographic Characteristics	The exposure models do not account for diurnal (i.e., work-related), seasonal (i.e., recreational uses, farm workers) or longer term (i.e., construction workforces) transient populations. This could be a significant source of uncertainty for transient populations near the site, but since these are not expected to be large populations, this is not expected to be significant for most reported consequence measures. However, early health effects could be highly sensitive to changes in the actual population distribution within a few miles of the site.
	There will be a variability in individual responses that is not captured in a discrete number of homogenous cohorts. However, with the relatively large number of cohorts modeled in the Level 3 PRA project, including the discretization of the general public into four timing cohorts over three spatial intervals, it is expected that the variability is likely to be captured and this is not expected to be a significant source of uncertainty.
	There will be changes in the distribution of population over the period of interest (i.e., immigration, emigration, births, deaths, etc.). that are not captured by a single population distribution. Some collective consequences, such as total health effects cases, population dose, economic impacts, etc., are relatively linear with respect to total population. This could be investigated with sensitivity analyses based on alternate site files, with different estimates for population growth, by selecting an alternate base year for the analysis.
PA/EC 3.4.2.2 Characterization of Exposure Pathways	Exposure parameters (i.e., breathing rates, fraction of time indoors/outdoors, crop consumption rates, etc.) do not explicitly account for variability within the exposed population. Information on the variability in important exposure parameters is available in the EPA Exposure Factors Handbook (EPA 2011). This is not expected to be a significant source of uncertainty except for late evacuees during very early releases, where there is the potential for exposure to the passing plume.
	Shielding factors are a function of the roughness of the surface on which the material is deposited, building type, location of deposited material (e.g., roof versus ground), location within structure, spectrum of emitted radiation, topography/land use, etc. These are all represented by single shielding factors. The effect of these factors is discussed in NUREG/CR-6526. The effect of variability in shielding factors was examined in draft NUREG/CR-7155. Shielding factors are expected to be a significant source of uncertainty.

Table 3-34 Uncertainties Related to Protective Action Parameters, Site Data, and Economic Factors (cont.)

PA/EC 3.4.2.2 Characterization of Exposure Pathways (continued)	The location of the individual, which affects the shielding afforded by structures, is a function of the behavior of the individual. For example, whether the individual is an agricultural or outdoor worker, an indoor worker, a nonactive adult, a child, etc., will affect how much time they spend in different locations, each of which would have its own shielding characteristics. The effect of these factors is discussed in NUREG/CR-6526. The effect of occupancy patterns (i.e., time spent in different locations) on shielding factors could be a significant source of uncertainty.
	The transfer of deposited material from the exterior to the interior of structures is subject to uncertainty. The efficiency of air exchange by ventilation systems, or by open or damaged windows or doors, will affect the ratio of outdoor to indoor air concentrations. Deposited material may also be transported indoors by foot traffic. The effect of these factors is discussed in NUREG/CR-6526. The effect of air exchange on shielding factors could be a source of uncertainty.
	Weathering and resuspension factors are based on empirical models derived from limited datasets. The applicability of those datasets to this specific site is uncertain. In addition, the rate at which material weathers can depend strongly on the type of initial deposition (i.e., material deposited by wet deposition may be more strongly bound than material deposited by dry deposition) and the type of surface on which the deposition occurs. For example, material deposited on roadways may be rapidly weathered by vehicular traffic, and material deposited on roofs may be washed off by rainfall following deposition; however, material deposited by dry deposition on walls may be removed quite slowly. The same factors will affect the degree to which deposited material can be resuspended and inhaled. The effect of these factors is discussed in NUREG/CR-6526.
	The estimation of location-specific individual exposure from ingestion (food, water, soil, etc.) is subject to uncertainty, particularly since food and water may be distributed away from the point of initial deposition.
	Parameters used for modeling food-chain transport are subject to uncertainty. Some of the parameters selected for elicitation in NUREG/CR-6523 include the rate at which deposited material migrates into soil, the rate at which the radioisotopes are fixed and unavailable for plant uptake, the fraction of deposited material that is taken into the plant via root uptake or foliar deposition, and the rate at which deposited material is resuspended onto plant surfaces by precipitation. Information on the uncertainty in these variables is provided in NUREG/CR-6136, NUREG/CR-6523, and Chapter 6 of Bixler et al. (2013). This could be a significant source of uncertainty for collective effects.
	Although computed results show that collectives doses from ingestion of surface water contaminated by deposition can be a noticeable contributor to overall population dose (on the order of 10 percent), the surface water ingestion model is highly simplified, and the parameters are subject to uncertainty. The

Table 3-34 Uncertainties Related to Protective Action Parameters, Site Data, and Economic Factors (cont.)

PA/EC 3.4.2.2 Characterization of Exposure Pathways (continued)	significance of this is uncertain but is believed to be low in relation to the uncertainties in food-chain modeling, because water quality is easily monitored.
	The start and duration of protective action phases (i.e., early, intermediate, and recovery) are approximate and may overlap or occur at slightly different times at different locations. This is not expected to be a significant source of uncertainty.
	The extent of agricultural interdiction following an accident is uncertain. A more stringent precautionary interdiction would lead to lower collective doses from food, but higher economic impacts from the loss of crop sales. This could be a significant source of uncertainty on both doses and costs, albeit in an offsetting fashion.
PA/EC 3.4.2.3 Evacuation, Sheltering, and KI Administration	As noted in Table 3-12, there is uncertainty in estimating the timing of GE declarations arising from station blackout sequences occurring during cold operating conditions. This is because there is no GE criterion during shutdown conditions that is equivalent to the SG-1 (Prolonged loss of all offsite and all onsite AC power) criterion that applies during at-power operations. For these scenarios it is therefore assumed that GE is declared via Emergency Director discretion (HG2). This uncertainty could be significant for early-phase exposures if the declaration of a GE were delayed sufficiently that the warning time was insufficient to allow evacuation of the EPZ prior to release.
	The timing of protective action recommendations, particularly recommendations for protective actions beyond the EPZ, are subject to uncertainty. The effect of different timings has been addressed in previous studies. This uncertainty may be subject to a cliff-edge effect, in that the timing is important to the extent that it affects whether the evacuation area is cleared prior to plume arrival. If the uncertainty in the timing does not result in exposure to the plume, then the effect may be insignificant. However, if the warning time is insufficient to allow clearance of the evacuation area, then doses from plume passage (cloudshine and cloud inhalation) to evacuating cohorts could be significant. A site-specific assessment of the uncertainty in evacuation times and speeds was conducted as part of the SOARCA Peach Bottom uncertainty analysis, as documented in NUREG/CR-7155.
	The fraction of the population that does not evacuate when ordered is unknown. Experience has shown that although most individuals will comply with evacuation orders, a small fraction of individuals may fail to evacuate. Information available in NUREG/CR-6864 (Identification and Analysis of Factors Affecting Emergency Evacuations) contains some information on the potential extent of non-evacuation, but much of the information is qualitative. This is not expected to be a significant source of uncertainty for population-dependent results within 20 miles because this population is expected to be a small fraction of the overall population within the evacuation zone.
	Although the effectiveness of KI is subject to uncertainty, it is not considered to contribute to the uncertainty in this analysis as it is not planned for use at this location.

Table 3-34 Uncertainties Related to Protective Action Parameters, Site Data, and Economic Factors (cont.)

PA/EC 3.4.2.3 Evacuation, Sheltering, and KI Administration (continued)	The magnitude and timing of shadow evacuation is subject to uncertainty. Shadow evacuation may reduce doses to those who are modeled as evacuating but could result in traffic congestion that could reduce evacuee travels speeds. This could lead to increased doses for the evacuee cohorts, but only if the effect resulted in evacuations that were incomplete before plume arrival.
	The effect of adverse weather, particularly rare or extreme events such as ice storms, high winds, etc., on protective actions is subject to uncertainty. Severe weather could affect both evacuee speed estimates because of degraded road conditions and increase the amount of time needed for notification and mobilization because of the potential loss of power or damage to notification systems. Also, to the extent that severe weather is correlated to the initiating event, there may be dependencies between the Level 1, 2, and 3 PRA portions of the model.
	The daily cost associated with short-term relocation (i.e., EVACST) is uncertain. The current model is based on per-diem rates in large cities and does not explicitly quantify the potential for the cost either of group shelters or of accommodation provided by private individuals (i.e., staying with family or friends outside the evacuation area). The significance of the early-phase aspect of relocation is not expected to be high, but the daily costs of relocation for longer periods could prove to be a significant source of uncertainty in economic estimates.
	Uncertainties in the traffic models used for evacuation time estimates will propagate forward into the evacuation model used in this analysis.
	Estimates for relocation times are uncertain, as the amount of time needed to identify, notify, and mobilize populations outside of the EPZ can be difficult to assess. Longer relocation times can increase radiological doses when groundshine is a significant contributor to dose, which is typically the case. A site-specific assessment of the effect of this was conducted as part of the SOARCA Peach Bottom uncertainty analysis, as documented in NUREG/CR-7155. This is not expected to be a significant source of uncertainty because for most release categories, evacuation has been explicitly modeled for areas where PAGs are expected to be exceeded. This could be a significant source of uncertainty for large releases with the potential for extensive early-phase relocation beyond the 20-mile evacuation zone.
PA/EC 3.4.2.4 Relocation and Interdiction Models	Long-term cleanup levels are uncertain, as decisions on cleanup would be made following the accident with interaction from multiple stakeholders. This effect was shown to be significant in NUREG/CR-6134 (Helton et al., 1995b). The effect of varying the habitability criteria has been examined in multiple studies (e.g., Mubayi et al. 1995]), demonstrating that there is a tradeoff between doses/health impacts and economic impacts (i.e., more stringent long-term levels reduce doses, but increase the extent of protective actions needed, thereby increasing costs). This could be a significant source of uncertainty on both doses and costs, albeit in an offsetting fashion.

Table 3-34 Uncertainties Related to Protective Action Parameters, Site Data, and Economic Factors (cont.)

PA/EC 3.4.2.4 Relocation and Interdiction Models (continued)	Alternate conceptual approaches exist for quantifying the economic impact of interdiction of land following an accident. The current approach in MACCS, referred to as a cost-based model, computes losses from depreciation and loss of use of property. Alternate approaches, such as input-output models, can be used to estimate the impact of disruptions of economic sectors. The significance of this is uncertain and could be examined with the use of a model that is based on input-output modeling.
	The economic impact of relocation and interdiction is uncertain. In particular, the values used to evaluate the depreciation (DPRATE) and the loss of use of interdicted property (DSRATE) are challenging to quantify. Lower depreciation and lower returns would reduce economic impacts, whereas higher depreciation and projected returns would increase the impacts. This could be a significant source of uncertainty in economic impacts.
	The length of the intermediate phase is uncertain. This affects both dose and cost, because weathering and radioactive decay can result in a significant drop in the dose rate over a period of months, but the costs of intermediate-phase relocation would rise approximately linearly with the duration of the intermediate phase. However, increasing the intermediate phase may lower the amount of land requiring decontamination, thereby partially offsetting the impact of a longer intermediate phase. The significance of this is uncertain. The effect of this could be examined with sensitivity analysis on the variable DUR_INTPHAS.
PA/EC 3.4.2.5 Decontamination Plan	Estimates of the costs of decontamination, particularly of the decontamination time and costs, are subject to uncertainty. As discussed in the text, commonly used values of per-capita and per-hectare costs from Sample Problem A are traceable to a reference in Burke et al. (1984) that does not appear to have been published. The values used for the Level 3 PRA project are based on ongoing work to update those values. This could be a significant source of uncertainty, but it should be noted that other cost components (e.g., the intermediate-phase costs and loss-of-use costs associated with the MACCS interdiction cost model) may be comparable to, or larger than, the decontamination cost component.
	The time needed to complete decontamination and re-establish occupancy is subject to considerable uncertainty. This is likely to be a significant source of uncertainty in total economic costs, as costs associated with loss of use of the land would accumulate with time.

Table 3-35 Potential Sensitivity Analyses to Address Uncertainties in Protective Action Parameters, Site Data, and Economic Factors

Analysis	Objective	MACCS Parameters to be Varied	Expected Results	Imple-mentation Method
PA_1	Increased relocation times	Relocation times (TIMHOT, TIMNRM)	Increased early-phase doses to non-evacuating cohorts; limited effect overall due to dominance of CHRONC results	Cyclic file set
PA_2	Examine uncertainty introduced by evacuation times	Reduced evacuation speeds (ESPEED) and increased evacuation delay (DLTEVA)	Potential increase in early-phase doses to late evacuating cohorts; limited effect overall due to dominance of CHRONC results	Cyclic file set
PA_3	Elimination of schools cohort to examine uncertainties introduced by assumptions about dismissal of schools at SAE to serve as shelters	Population files with no population assigned to schools cohorts	Negligible effects overall; slight increase in collective and population-weighted risks due to larger population in 10–15-mile region	Alternate input decks
PA_4	Examine uncertainty associated with shielding factors	GSHFAC, LGSHFAC, CSFACT, PROTIN, LPROTIN, SKPFAC sampled from distributions in Tables 3.4-6 and 3.4-7 of NRC (2022a)	Doses expected to be proportional to shielding factors	WinMACCS sampling
PA_5	Examine uncertainty associated with breathing rate	BRRATE/LBRRATE sampled from distributions in Table 3.4-8 of NRC (2022a)	Doses expected to linearly increase with breathing rate for cohorts exposed during plume passage	WinMACCS sampling
PA_6	Examine uncertainty introduced by EAL declarations	Increase DLTSHL for cohorts within ten miles for SBO scenarios	Limited effects expected due to expected dominance of CHRONC results	Alternate input decks

Table 3-35 Potential Sensitivity Analyses to Address Uncertainties in Protective Action Parameters, Site Data, and Economic Factors (cont.)

Analysis	Objective	MACCS parameters to be varied	Expected Results	Imple-mentation Method
EC_1	Examine influence of phase durations on dose and cost results	Phase durations (DUR_INTPHAS, TIMDEC) set to range of values	Net effect is uncertain. Reduced phase durations hypothesized to reduce costs. However, reductions in intermediate-phase duration may result in more land subject to decontamination.	Cyclic file set
EC_2	Examine influence of assumptions about return criteria on dose and cost results	DSCRLT	Population doses and costs expected to be proportional/inversely proportional to habitability criteria	Cyclic file set
EC_3	Examine influence of decontamination plan (levels and unit costs) on dose and cost results	CDFRM, CDNFRM, DSRFCT	Increased unit costs expected to increase economic impacts. Very high unit costs may result in increased condemnation of farmland and non-farmland, resulting in higher costs but lower doses.	Cyclic file set

3.5 Dosimetry (DO)

3.5.1 Assumptions and Known Limitations

The following assumptions and limitations are reproduced from NRC (2022a):

- The assumptions and limitations of the MACCS code apply (i.e., only one chemical form for each nuclide, etc.). These are discussed in more detail in NRC (2022a).

- The list of organs that can be used is hardwired within the version of the MACCS code used to develop the input decks Organs not included on this list, even though present in the DCF files, cannot currently be used in MACCS calculations. Due to a limitation of eight lifetime dose coefficients representing specific organs (excluding the effective pseudo-organ, L-ICRP60ED) that are read from the DCF file, MACCS calculates the dose to seven specific cancer sites and one residual cancer site.

- To estimate residual cancers, the dose coefficients for the pancreas are used as a surrogate for dose to soft tissue. Because MACCS does not currently read the data for the pancreas from the dose coefficient file, values of the dose coefficients for the pancreas were copied into the organ called bladder wall. Thus, residual cancers are associated with the organ called bladder wall, which contains dose coefficients for the pancreas.

- Dose coefficients are based on the most recent update released for the Federal Guidance Report (FGR), which is currently FGR-13 (EPA, 1999a).

- The use of age and gender average dose conversion factors for all cohorts, including special facilities such as schools or restricted access industrial facility workers, is assumed to reasonably reflect average characteristics of the populations in those cohorts.

- The inhalation coefficients for aerosols assume an activity median aerodynamic diameter of 1 μm, a geometric standard deviation of 2.5, a density of 3 g/cm^3, and a shape factor of 1.5.

- The lung absorption types for aerosols are consistent with Runkle and Ostmeyer (1985) for severe accidents at light water reactors. The lung absorption type for a specific radionuclide may be viewed by opening the DCF file and reading the corresponding value in lines 32 through 856.

- FGR-13 assigned gastrointestinal uptake f_1 values for ingestion based on the form expected to persist in the environment, and these values are not necessarily consistent with the f_1 values used in the computation of inhalation dose coefficients.

No supplemental assumptions were identified as part of the LPSD analysis.

3.5.2 Technical Discussion

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.5.3 MACCS Dosimetry Input Parameter Summary

A summary of the MACCS input parameters related to dosimetry is provided in Table 3-36, reproduced from Table 3.5-6 of NRC (2022a).

Table 3-36 Summary of MACCS Input Parameters Related to Dosimetry

Variable	Description	Value	Source
DCF_FILE	Name of dose coefficient file	FGR13GyEquivDCF.INP	Section 3.5
ORGFLG	Doses to be calculated for specified organ	All TRUE for FGR-13	

3.5.4 Identification and Discussion of Uncertainties Related to Dosimetry

The following identification and discussion of uncertainties is reproduced from NRC (2022a). No supplemental discussion was identified as necessary for the LPSD analysis.

There are several sources of uncertainty in the calculation. These are listed in Table 3-37 (reproduced from Table 3.5-7 of NRC 2022a), which was generated by reviewing each subsection to identify and characterize the sources of uncertainty. Table 3-38 (reproduced from Table 3.5-8 of NRC 2022a) provides a list of potential candidate sensitivity analyses based on a subset of the uncertainties identified in Table 3-37. A candidate sensitivity analysis has only been identified for those uncertainties that are considered readily amenable to quantitative modeling using MACCS.

Information on the uncertainties in parameters for internal dosimetry models was evaluated in Goossens et al. (1998). An evaluation of the uncertainties in the MACCS dose coefficients is discussed in Section 2.1.5 of Eckerman (2012), based on the analyses in Pawel et al. (2007). Tables of the geometric mean and standard deviations for inhalation intakes in the dose factors are provided in Appendix B of Eckerman (2012) for 58 radionuclides and the 8 MACCS cancer sites. Uncertainties in the ingestion coefficients were not considered in that report as the SOARCA project did not model the ingestion pathway. The dominant sources of uncertainties in the inhalation dosimetric models were considered to include the fraction of inhaled material deposited in the respiratory tract, the rate of absorption from the respiratory tract to blood, the gastrointestinal absorption fraction (f1), the systemic biokinetic model, and specific energy values for certain combinations of source and target organs and radiation types. Uncertainties in dosimetric quantities related to both groundshine and chronic inhalation doses were investigated in SNL (2016) and SNL (2019). For the releases analyzed in those scenarios, uncertainties in groundshine and long-term inhalation dosimetry generally did not show up as a significant source of uncertainty for health risks.

Table 3-37 Uncertainties Related to Dosimetry

3.5.2.1 MACCS Organ Definitions	The organ list in MACCS is based on the organs for which risk factors were provided in FGR-11/12. The mapping of risk information from FGR-13 to the reduced set of organs in MACCS is a source of model uncertainty.
3.5.2.2 Dose Coefficient File	Uncertainties in the dosimetric (e.g., biokinetic parameters) models would propagate forward into the DCF file. Also, the chemical and physical form of inhaled or ingested material will affect the intake, deposition, and distribution of inhaled material within the body. Sources of uncertainty in internal dosimetry were identified and discussed in Goossens et al. (1998), as well as in FGR-13 and in Eckerman (2012).
3.5.2.3 External Dose Coefficients	Any uncertainties in the calculation of external dose coefficients would propagate forward into the calculation. Also, external dose coefficients are based on exposure from an ideal uniform surface. As discussed previously, the surface on which the material is deposited is likely to be nonuniform. Sources of uncertainty in external dosimetry were discussed in Goossens et al. (1997).
3.5.2.4 Acute Inhalation Dose Coefficients	The inhalation dose coefficient is modeled based on an instantaneous intake of inhaled material. The effect of a more continuous or time-dependent intake is not modeled. Also, there could be uncertainties in the weighting factors the absorbed dose rates used to assess the effect of dose fractionation from inhaled materials. Sources of uncertainty in early health effects, which can arise from acute inhalation exposures, were discussed in Haskins et al. (1997).
3.5.2.5 Chronic Inhalation and Ingestion Dose Coefficients	The dose coefficients are modeled based on an instantaneous intake of material. The effect of a more continuous or time-dependent intake is not modeled. Sources of uncertainty in late health effects, which can arise from chronic exposures, were discussed in Little et al. (1997). The effects of uncertainties in inhalation dose coefficients were analyzed as part of the SOARCA Peach Bottom uncertainty analysis, as documented in NUREG/CR-7155.

Table 3-38 Potential Sensitivity Analyses to Address Uncertainties Related to Dosimetry

Analysis	Objective	MACCS Parameters to be Varied	Expected Results	Implementation Method
DO_1	Examine influence of shielding factors on results	Shielding factors (GSHFAC/PROTIN/CSFACT)	All impacts expected to be proportional to shielding assumptions	Cyclic file set
DO_2	Examine uncertainty associated with inhalation DCF values	DCF values sampled using values from Appendix B of (Eckerman 2012)	Limited impacts because long-term doses dominated by groundshine	WinMACCS sampling
DO_3[1]	Examine the effect of explicitly modeling all organs identified in FGR-13 cancer risk models	DCF file, CFRISK/CIRISK, ORGFLG	Total cancer risk results not expected to change significantly	Alternate input decks

1. *DO_3 would take advantage of the capabilities introduced with WinMACCS 3.11 to explicitly model risks to any organ specified in the DCF file rather than the nine hardwired organs available in WinMACCS 3.10 and earlier.*

3.6 Health Effects (HE)

3.6.1 Assumptions and Known Limitations

The following assumptions and limitations are reproduced from NRC (2022a):

- The availability of health effects models is limited to the capabilities incorporated into the MACCS code.
- Early injuries are modeled to aid in evaluating margin to early fatality effects.
- The effect of low doses on health is uncertain. A linear, no threshold (LNT) dose-response model is used, which assumes that any radiation exposure at all carries some risk of latent cancer.
- The mortality risk coefficients are based on an average over the age and gender of the U.S. population.
- Mortality risk coefficients for the cancer sites are assumed to be independent and not correlated.
- The uncertainty in the cancer mortality risk coefficient is assumed to be lognormally distributed.

No supplemental assumptions were identified as part of the LPSD analysis.

3.6.2 Technical Discussion

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

3.6.3 MACCS Health Effects Input Parameter Summary

A summary of the MACCS input parameters related to health effects is provided in Table 3-39 (reproduced from Table 3.6-5 of NRC 2022a).

Table 3-39 Summary of MACCS Input Parameters Related to Health Effects

Variable	Description	Value	Source
NUMEFA	Number of Early Fatality Effects	3	Section 3.6.2.1 of NRC (2022a)
EFFTHR	Threshold Dose to Target Organ (Gy-Equiv Sv)		
	A-RED MARR	2.32	
	A-LUNGS	13.6	
	A-STOMACH	6.5	
EFFACA	LD50 for Early Fatality Types (Gy-Equiv Sv)		
	A-RED MARR	5.6	
	A-LUNGS	23.5	
	A-STOMACH	12.1	
EFFACB	Shape Factor for Early Fatality Types		
	A-RED MARR	6.1	
	A-LUNGS	9.6	
	A-STOMACH	9.3	
NUMEIN	Number of Early Injury Effects	7	
EISUSC	Susceptible Population Fraction	1 for all health effects	
EINAME	Early Injury Effect Names and Corresponding Organ		
	PRODROMAL VOMIT	A-STOMACH	
	DIARRHEA	A-STOMACH	
	PNEUMONITIS	A-LUNGS	
	SKIN ERYTHRMA	A-SKIN	
	TRANSEPIDERMAL	A-SKIN	
	THYROIDITIS	A-THYROID	
	HYPOTHYROIDISM	A-THYROID	

Table 3-39 Summary of MACCS Input Parameters Related to Health Effects (cont.)

Variable	Description	Value	Source
EITHRE	Early Injury Dose Threshold (Gy-Equiv Sv)		Section 3.6.2.1 of NRC (2022a)
	PRODROMAL VOMIT	0.5	
	DIARRHEA	1	
	PNEUMONITIS	9.2	
	SKIN ERYTHRMA	3	
	TRANSEPIDERMAL	10	
	THYROIDITIS	40	
	HYPOTHYROIDISM	2	
EIFACA	LD50 For Early Injuries (Gy-Equiv Sv)		
	PRODROMAL VOMIT	2	
	DIARRHEA	3	
	PNEUMONITIS	16.6	
	SKIN ERYTHRMA	6	
	TRANSEPIDERMAL	20	
	THYROIDITIS	240	
	HYPOTHYROIDISM	60	
EIFACB	Shape Factor for Early Injuries		
	PRODROMAL VOMIT	3	
	DIARRHEA	2.5	
	PNEUMONITIS	7.3	
	SKIN ERYTHRMA	5	
	TRANSEPIDERMAL	5	
	THYROIDITIS	2	
	HYPOTHYROIDISM	1.3	
DOSMOD	Dose-Response Model Flag	LNT	Section 3.6.2.2 of NRC (2022a)
ACTHRE	Linear Dose-Response Threshold	0	
DOSEFA	Cancer Dose-Response Linear Factors	1 for all organs	
DOSEFB	Cancer Dose-Response Quadratic Factors	0 for all organs	
ACSUSC	Population Susceptible to Cancer	1.0 for all cancers	
NUMACA	Number of Latent Cancer Health Effects	8	

Table 3-39 Summary of MACCS Input Parameters Related to Health Effects (cont.)

Variable	Description	Value	Source
ACNAME	Latent Cancer Effect		Section 3.6.2.2 of NRC (2022a)
	Cancer Type 1	LEUKEMIA	
	Cancer Type 2	BONE	
	Cancer Type 3	BREAST	
	Cancer Type 4	LUNG	
	Cancer Type 5	THYROID	
	Cancer Type 6	LIVER	
	Cancer Type 7	COLON	
	Cancer Type 8	RESIDUAL	
DDTHRE	Threshold for Applying Dose-Dependent Reduction Factor (Sv)	0.2	
DDREFA	Dose-Dependent Reduction Factor		
	Cancer Type 1	2	
	Cancer Type 2	2	
	Cancer Type 3	1	
	Cancer Type 4	2	
	Cancer Type 5	2	
	Cancer Type 6	2	
	Cancer Type 7	2	
	Cancer Type 8	2	
CIRISK	Lifetime Cancer Injury Risk Factors (1/Sv)		
	Cancer Type 1	0.0113	
	Cancer Type 2	0.000271	
	Cancer Type 3	0.0101	
	Cancer Type 4	0.0208	
	Cancer Type 5	0.00648	
	Cancer Type 6	0.00316	
	Cancer Type 7	0.0378	
	Cancer Type 8	0.169	
CFRISK	Lifetime Cancer Fatality Risk Factors (1/Sv)		
	Cancer Type 1	0.0111	

Table 3-39 Summary of MACCS Input Parameters Related to Health Effects (cont.)

Variable	Description	Value	Source
	Cancer Type 2	0.00019	Section 3.6.2.2 of NRC (2022a)
	Cancer Type 3	0.00506	
	Cancer Type 4	0.0198	
	Cancer Type 5	0.000648	
	Cancer Type 6	0.003	
	Cancer Type 7	0.0208	
	Cancer Type 8	0.0493	

3.6.4 Identification and Discussion of Uncertainties Related to Health Effects Modeling

The following identification and discussion of uncertainties is reproduced from NRC (2022a). No supplemental discussion was identified as necessary for the LPSD analysis.

There are several sources of uncertainty in the calculation. These are listed in Table 3-40 below (reproduced from Table 3.6-6 of NRC 2022a), which was generated by reviewing each subsection to identify and characterize the sources of uncertainty. Table 3-41 (reproduced from Table 3.6-7 of NRC (2022a)) provides a list of potential candidate sensitivity analyses based on a subset of the uncertainties identified in Table 3-40.

It is unclear what health consequences, if any, are attributable to very low radiation exposure. Uncertainties in cancer risk estimation are discussed in Section 5.7 of NUREG-1935 (NRC 2012). As discussed in NUREG-1935, “the International Commission on Radiological Protection (ICRP), the National Academy of Sciences, and the United Nations Scientific Committee on the Effects of Atomic Radiation have each indicated that the current scientific evidence is consistent with the hypothesis that an LNT dose-response relationship exists between exposure to ionizing radiation and the development of cancer in humans.” However, in its most recent recommendations (ICRP 2007), the ICRP warned that “the computation of cancer deaths based on collective effective doses involving trivial exposures to large populations is not reasonable and should be avoided,” but that report did not provide a specific dose limit below which quantitative cancer risk estimation should be avoided. A review of ICRP and IAEA literature described in Section 5.7 of NUREG-1935 suggests that doses on the order of a few millirem per year may be considered trivial. In contrast, the Health Physics Society has developed a position paper (HPS 2010) concluding that quantitative estimates of risk should be limited to individuals receiving an annual whole-body dose greater than 0.05 Sv (5 rem) or a lifetime dose greater than 0.1 Sv (10 rem). It should be noted that, for much of the long-term phase affected population, intermediate and long-term phase protective actions modeled in MACCS may reduce computed doses to levels below those for which the HPS position statement would recommend performance of quantitative cancer risk estimation. A useful discussion on the attribution of cancer risk may be found in Annex X of Volume 4 of IAEA (2015). Table X-1 of that annex shows dose ranges and the inferences that may be drawn regarding cancer risks to individuals or populations regarding exposure to different levels of radiation. Because MACCS

can report the size of population exceeding specified dose levels, these qualitative terms are used to help define dose outputs to interpret MACCS results regarding latent fatality risk.

An approach to addressing the uncertainty in stochastic health effects at low doses is to evaluate how the risks would change if computed cancer risks were limited to only higher doses. The MACCS computer code has a capability to model latent-cancer risk subject to annual (DTHANN) and lifetime (DTHLIF) effective dose thresholds. This model is selected by choosing the Annual Threshold dose model on the Dose tab of the Project Properties form in WinMACCS. In WinMACCS a sequence of annual dose threshold values can be entered as a set of Dose Model parameters on the Annual Threshold form. The last value entered applies to all subsequent years. The thresholds, DTHANN and DTHLIF, are always specified based on effective dose even though specific organ doses are used in the dose-response model. If the lifetime threshold DTHLIF is exceeded by the cumulative, effective dose over the exposure period specified in the input, then MACCS uses the sum of all annual, equivalent doses to an organ, without adjustment, to calculate the latent-cancer risk for that organ, the same as it would with a no threshold hypothesis. If an annual threshold DTHANN is exceeded but the lifetime threshold is not, then MACCS includes that annual dose, without adjustment, to estimate a contribution to latent-cancer risk. If the effective dose is less than the annual threshold for that year and the lifetime threshold is not exceeded, then that dose is assumed to have no effect on cancer induction. After MACCS calculates all the doses that contribute to cancer induction, it applies the factors described in Section 3.6.2 to calculate latent-cancer risks arising from threshold-adjusted doses to various organs.

An alternate approach to addressing the uncertainty in stochastic health effects at low doses, including the choice of a potential threshold, would be to sample dose and dose-rate effectiveness factor (DDREF) values from the distribution provided in Table 3.6-3 of NRC (2022a), which was adapted from Table 3 of Eckerman (2012). As noted by ICRP (2005), “Unless the existence of a threshold is assumed to be virtually certain, the effect of introducing the uncertain possibility of a threshold is equivalent to that of an uncertain increase in the value of DDREF, i.e., merely a variation on the result obtained by ignoring the possibility of a threshold.” Alternate sources of DDREF distributions identified by ICRP (2005) include those provided in NCRP (1997), EPA (1999b), Grogan et al. (2001), and NCI/CDC (2003).

Consistent with the SOARCA analyses and current NRC policy for regulatory applications, the base-case dose-response model used in this analysis to evaluate stochastic effects is the LNT model. Sensitivities of different truncation levels (that limit the quantified health effects to those arising from doses exceeding a predefined threshold) could also be investigated to understand how the risks would change if computed health risks were limited to doses exceeding a predefined threshold. Limited sensitivity analyses were carried out in the L3PRA project to better understand the attribution of cancer risk as a function of dose level. For example, see sensitivity analysis HE_2 identified in Table 3-41 and the results of performing that sensitivity analysis in Chapter 4. In addition, intermediate results, such as the reporting of the peak dose as a function of distance (MACCS Type A output), and the size of the population exceeding specific dose levels (MACCS Type 3 output), may be examined for insights.

Table 3-40 Uncertainties Related to Health Effects Modeling

3.6.2.1 Acute Health Effects	There is uncertainty in the dose-response function parameters used to estimate acute health effects. Lethal doses for different fatal effects (e.g., hematopoietic syndrome, pulmonary syndrome, gastrointestinal syndrome) are a function both dose and the dose rate, as well as the overall health of the exposed individual and the amount of medical care that is available. The potential uncertainty in these parameters has been assessed in NUREG/CR-6545 and distributions to characterize these values are available in Chapter 6 of Bixler et al. (2013). In addition, the effects of these uncertainties were analyzed in the SOARCA Peach Bottom Uncertainty Analyses, as documented in NUREG/CR-7155. In the minute frequency of cases where a non-zero early fatality was calculated, the variables describing the uncertainty in hematopoietic syndrome were found to be important.
3.6.2.2 Stochastic Health Effects	As discussed in Eckerman (2012), sources of uncertainty in cancer mortality risk coefficients include sampling variations, errors in dosimetry, errors in ascertainment of cause of death, modeling of the dependence on age at exposure and time since exposure, transport of risk estimates from a study group to the U.S. population, extrapolation to low DDREF, and, for high-LET radiation, uncertainty in RBE. Eckerman (2012) provided quantitative estimates of the uncertainty in these mortality risk coefficients. In addition, the effects of uncertainties stemming from DDREF and CFRISK were analyzed in the SOARCA Peach Bottom Uncertainty Analyses, as documented in NUREG/CR-7155. The two variables for the "Residual" organ (representative soft tissue/pancreas) were found to be important for latent fatality risk results using the LNT dose-response model.
	There is uncertainty in in the estimates of cancer induction due to low doses and/or dose rates. Some of this uncertainty is reflected in the dose and dose-rate effectiveness factor (DDREF), as discussed in NUREG/CR-6555. Sensitivity studies can be conducted on the parameters used to implement the DDREF to explore the uncertainty in the shape of the dose-response curve. However, to the extent that modeled protective actions are successful at reducing doses, the computed doses in the consequence will be well below the level from which epidemiological data is available (and clearly in the range where a DDREF should be applied). Sensitivity analyses using different truncation levels can demonstrate how many health effects cases arise from different doses/dose rates. As documented in NUREG/CR-7155, results using two alternate linear-with-threshold dose-response models were analyzed in the SOARCA Peach Bottom Uncertainty Analyses, including sensitivity analyses of the effects of different habitability criteria in conjunction with alternate threshold models.

Table 3-41 Potential Sensitivity Analyses to Address Uncertainties Related to Health Effects

Analysis	Objective	MACCS Parameters to be Varied	Expected Results	Implementation Method
HE_1	Examine uncertainty in early health effect parameters	Early fatality parameters set to 10^{th} and 90^{th} percentile value from NUREG/CR-7161 (Bixler et al. 2013)	Impact will be noticeable for 1GPT and NE, but not for other cohorts. Early fatality range will be noticeably affected.	Cyclic file set
HE_2	Examine uncertainty associated with low-dose cancer risk estimation	Truncation to background and HPS position statement using parameters given in Table 3-42 and Table 3-43	Dose truncation will significantly affect cancer risk but no other outputs.	Alternate input decks
HE_3	Examine uncertainty associated with cancer risk estimation	Sample CFRISK values from the distributions provided in Table 3.6-3 of NRC (2022a)	Cancer risks expected to be proportional to changes in risk coefficients.	WinMACCS sampling
HE_4	Examine uncertainty associated with the DDREF used for low-dose cancer risk estimation	Sample DDREF values from the distributions provided in Table 3.6-3 of NRC (2022a) or alternate published sources of DDREF distributions	Cancer risks expected to be inversely proportional to changes in DDREF values.	WinMACCS sampling

Table 3-42 Parameters for the 10 mrem Annual Threshold Latent-Cancer Quantification Model

Variable	Description	Value	Source
DOSMOD	Dose-Response Model Flag	AT	Section 3.6.4
DTHNUM	Number of Annual Dose Thresholds	1	
DTHANN	Annual Dose Threshold (Sv/yr)	0.0001	
DTHLIF	Lifetime Dose Threshold (Sv)	-	

Table 3-43 Parameters for the HPS Threshold Latent-Cancer Quantification Model

Variable	Description	Value	Source
DOSMOD	Dose-Response Model Flag	AT	Section 3.6.4
DTHNUM	Number of Annual Dose Thresholds	1	
DTHANN	Annual Dose Threshold (Sv/yr)	0.05	
DTHLIF	Lifetime Dose Threshold (Sv)	0.10	

3.7 Output Control

This section is included to maintain section numbering consistent with NRC (2022a). For the LPSD analysis, no changes were made relative to the reactor at-power analysis.

4 RESULTS

The following discussion is abridged from Section 4 of NRC (2022a). Like the reactor at-power analyses, the current MACCS LPSD analyses were computed using MACCS Version 3.11.2. For the reactor at-power analysis, the details of the computational methodology for importing MELCOR source terms, estimating source-term-specific protective action parameters, developing source-term-specific input decks, and executing the analyses are documented in NRC (2022a). The same methodology was used for the LPSD analyses. The methodology allowed the source terms to be imported and appropriate input parameters developed in a relatively automated fashion, which reduces the potential for data entry errors and increases the traceability of the analysis. The MACCS calculations were performed in individual WinMACCS project files corresponding to the source terms from the Level 2 PRA MELCOR analyses defined in Table 3-9. These project files contain the event-specific source terms and the corresponding source-term-specific emergency preparedness values. All project files were developed from a single master project file which defined non-source-term-specific parameter values for all potential cohorts. As discussed in Section 3.4, the number of cohorts included for a given source term was accounted for by using the master project file together with an EP-model-specific site file. The project files are grouped into three EP models corresponding to the distance to which evacuation was modeled, and these EP models were further subdivided based on whether a school population between 10–15 miles could be in session given the timing of the event. This resulted in a total of five base-case project files, varying only by the site file used in each (see Table 3.4-5 of NRC 2022a).

For the modeling choices and associated parameters that are generic for all the calculations, project staff reviewed (and updated, as appropriate) all the values in the base project files with those identified in the MACCS Input Summary Tables in the respective subsections of Section 3. The source terms from the MELCOR analysis and the source-term-specific EP values were incorporated separately using parameter update files imported into WinMACCS to update the base-case project files. These source-term-specific EP values were generated by developing a methodology adapted from Appendix A of Jones et al. (2015). The source term import files and corresponding EP import files were then imported into copies of the base project files, as appropriate, to create the unique project files.

Consistent with the approach in Breeding et al. (1990) and in Mubayi et al. (1995), only mean values for each of the source terms were extracted for tabulation in this report. In this summary section, MACCS results have been tabulated for the set of output measures identified in Section 3.7. The mean values reported in these tables represent a weighted average across all weather trials. Review of intermediate results demonstrates that there can be significant variability in results across weather trials, which is not captured in a mean value. For the outputs selected for tabulation, complementary cumulative distribution function (CCDF) curves were constructed to display the variability across weather conditions. When CCDF curves for individual source terms are weighted by their respective frequencies, they may be summed to yield a picture of the combined risk, considering both the variability across weather conditions and the relative likelihood of the different release categories.

The results presented in this section were extracted from individual MACCS output files for each release category. Execution of the MACCS code produces results as text and binary files. For this report, a Python 2.7 script was developed to extract results from individual MACCS output files into a consistent database format. Use of a script allowed the extraction to be performed

more flexibly, as the operation of the script could be controlled by DOS batch files, and the resulting files concatenated to rapidly generate a complete database of different types of MACCS results from all code runs. These concatenated files were then postprocessed using Excel or Python to yield the tables and figures in this report.

Four summary tables (Table 4-1 through Table 4-4) are provided in this section with the mean values for the outputs selected for potential tabulation. The results are given conditional on the occurrence of individual release categories (i.e., unweighted), as well as a frequency-weighted sum across all release categories to include consideration of the relative frequency of each type of release. In addition, selected measures from the Level 2 PRA analyses are provided to assist in interpreting results. These include the frequency of occurrence for each release category, the cumulative cesium release, the cumulative iodine release, and the warning time (defined as the elapsed time between the projected general emergency declaration and the time of the first significant release). A more detailed discussion of each result type is included in subsections of this section. These discussions provide relevant intermediate results, such as the contributions from different population cohorts to dose or health risk. Finally, CCDF curves illustrating the variability across weather conditions for different release categories, as well as the composite CCDF representing a frequency-weighted sum of the CCDF curves for individual release categories, are given at the end of each subsection.

One item of which the reader should be aware is that certain types of outputs related to populations (i.e., total cases of early or latent fatalities, affected populations, etc.), may report values of less than one person. Values of less than a single person may occur as the result of weighting small populations by low values, usually arising from the combination of low values for the likelihood of being in a specific cohort and relatively infrequent weather conditions. For example, in a hypothetical example of a population of 100 persons, if there is a 0.5% chance of non-evacuation, the size of that population would be 0.5 persons. If the combination of wind direction and meteorological conditions placed that particular population at risk of elevated exposure for less than 10% of all weather samples, the resulting affected population would be reported as a value of 0.05 persons.

Table 4-1 Summary of Dose Measures (Conditional Mean Value Across All Weather Trials)

Release Category	Freq[1] (/yr)	Cumul. Cesium Release (MCi)	Cumul. Iodine Release (MCi)	Warning Time (hr)	Collective Total Effective Dose (person-rem)		Population Exceeding Early-Phase Total Effective Dose of 10 rem (persons)[3]	Population Exceeding Early-Phase Acute Red Bone Marrow Dose of 10 rad-eq (persons)[3]
					0–50 miles	0–100 miles		
All[2] (per yr)	1.2E-05	1.9E-05	6.0E-05		3.6E+00	8.9E+00	5.4E-04	3.3E-07
SD-ISLOCA	1.3E-07	8.0E-01	8.3E+00	7	2.9E+05	5.9E+05	1.2E-01	4.0E-03
SD-CIF	1.7E-06	1.8E+00	2.6E+00	95	5.7E+05	1.2E+06	3.7E-02	1.2E-04
SD-COPEN-RCSINTACT	2.7E-07	7.1E+00	7.1E+01	2	1.1E+06	3.4E+06	1.6E+01	8.2E-02
SD-COPEN-RCSVENT	1.3E-07	2.2E+01	1.3E+02	2	1.4E+06	4.6E+06	3.6E+03	2.2E+00
SD-COPEN-HEADOFF	7.8E-08	2.4E+01	4.5E+01	52	1.4E+06	4.4E+06	8.8E+02	1.9E-01
SD-ECF	5.1E-10	3.0E-01	1.6E+00	~64	2.4E+05	4.5E+05	-	-
SD-CF-Before-CD	2.1E-06	4.2E+00	6.1E+00	103	7.7E+05	2.0E+06	2.4E-01	3.0E-03
SD-ICF-BURN	1.7E-06	1.6E-01	1.4E+00	~85	2.2E+05	4.5E+05	2.0E-06	-
SD-LCF	5.5E-08	5.2E-04	2.0E-03	>156	1.6E+03	2.3E+03	-	-
SD-BMT	1.2E-07	4.7E-05	5.2E-04	>140	1.0E+02	1.5E+02	-	-
SD-NOCF	6.1E-06	2.6E-04	1.4E-04	>138	5.9E+02	8.1E+02	-	-

1. Frequency values were taken from Table 2-74 of NRC (2025).

2. Results are a frequency-weighted sum of all release categories.

3. Results are integrated across the entire modeling domain.

Note: Dashes represent MACCS results that are identically zero.

Table 4-2 Summary of Early Health Effect Measures (Conditional Mean Value Across All Weather Trials)

Release Category	Freq[1] (/yr)	Cumul. Cesium Release (MCi)	Cumul. Iodine Release (MCi)	Warning Time (hr)	Individual Early Fatality Risk, 0–1.8 mile	Early Fatality Cases, 0–50 mi (persons) [2]	Early Injury (Prodromal Vomiting) Cases, 0–50 mi (persons) [2]
All[3] (per yr)	1.2E-05	1.9E-05	6.0E-05		1.4E-12	3.5E-11	8.8E-10
SD-ISLOCA	1.3E-07	8.0E-01	8.3E+00	7	-	-	1.4E-07
SD-CIF	1.7E-06	1.8E+00	2.6E+00	95	-	-	-
SD-COPEN-RCSINTACT	2.7E-07	7.1E+00	7.1E+01	2	-	-	2.2E-05
SD-COPEN-RCSVENT	1.3E-07	2.2E+01	1.3E+02	2	1.1E-05	2.7E-04	6.6E-03
SD-COPEN-HEADOFF	7.8E-08	2.4E+01	4.5E+01	52	1.4E-08	3.6E-07	2.6E-04
SD-ECF	5.1E-10	3.0E-01	1.6E+00	~64	-	-	-
SD-CF-Before-CD	2.1E-06	4.2E+00	6.1E+00	103	-	-	-
SD-ICF-BURN	1.7E-06	1.6E-01	1.4E+00	~85	-	-	-
SD-LCF	5.5E-08	5.2E-04	2.0E-03	>156	-	-	-
SD-BMT	1.2E-07	4.7E-05	5.2E-04	>140	-	-	-
SD-NOCF	6.1E-06	2.6E-04	1.4E-04	>138	-	-	-

1. Frequency values were taken from Table 2-74 of NRC (2025).

2. Although the output statement tabulated health effect cases out to 50 miles, early fatalities (if any), are limited to much closer distances than 50 miles (e.g., see Table 4.2-4 for the range at which early fatalities could occur).

3. Results are a frequency-weighted sum of all release categories.

Note: Dashes represent MACCS results that are identically zero.

Table 4-3 Summary of Latent Health Effect Measures (Conditional Mean Value Across All Weather Trials)

Release Category	Freq[1] (/yr)	Cumul. Cesium Release (MCi)	Cumul. Iodine Release (MCi)	Warning Time (hr)	Individual Latent Fatality Risk, 0–10 mi	Total Latent Fatality Cases (persons)	
						0–50 mi	0–100 mi
All[2] (per yr)	1.2E-05	1.9E-05	6.0E-05		4.5E-09	1.8E-03	4.6E-03
SD-ISLOCA	1.3E-07	8.0E-01	8.3E+00	7	5.1E-04	1.5E+02	3.0E+02
SD-CIF	1.7E-06	1.8E+00	2.6E+00	95	7.9E-04	3.0E+02	6.1E+02
SD-COPEN-RCSINTACT	2.7E-07	7.1E+00	7.1E+01	2	1.1E-03	5.4E+02	1.7E+03
SD-COPEN-RCSVENT	1.3E-07	2.2E+01	1.3E+02	2	9.6E-04	7.1E+02	2.4E+03
SD-COPEN-HEADOFF	7.8E-08	2.4E+01	4.5E+01	52	1.0E-03	6.7E+02	2.3E+03
SD-ECF	5.1E-10	3.0E-01	1.6E+00	~64	6.4E-04	1.2E+02	2.4E+02
SD-CF-Before-CD	2.1E-06	4.2E+00	6.1E+00	103	8.6E-04	4.0E+02	1.1E+03
SD-ICF-BURN	1.7E-06	1.6E-01	1.4E+00	~85	4.7E-04	1.2E+02	2.3E+02
SD-LCF	5.5E-08	5.2E-04	2.0E-03	>156	8.0E-06	6.5E-01	1.0E+00
SD-BMT	1.2E-07	4.7E-05	5.2E-04	>140	2.2E-07	3.2E-02	5.4E-02
SD-NOCF	6.1E-06	2.6E-04	1.4E-04	>138	2.3E-06	2.2E-01	3.4E-01

1. Frequency values were taken from Table 2-74 of NRC (2025).

2. Results are a frequency-weighted sum of all release categories.

Table 4-4 Summary of Land Contamination, Affected Population, and Economic Cost Measures (Conditional Mean Value Across All Weather Trials)

Release Category	Freq[1] (/yr)	Cumul. Cesium Release (MCi)	Cumul. Iodine Release (MCi)	Warn. Time (hr)	Area Exceeding 555 kBq/m^2 Cs-137, (mi^2)		Population Relocated during Intermediate Phase (persons)		Total Economic Costs (2015$)	
					0–50 mi	0–100 mi	0–50 mi	0–100 mi	0–50 mi	0–100 mi
All[2] (per yr)	1.2E-05	1.9E-05	6.0E-05		5.8E-03	8.7E-03	3.2E-01	4.6E-01	7.2E+04	1.1E+05
SD-ISLOCA	1.3E-07	8.0E-01	8.3E+00	7	3.2E+02	3.3E+02	8.9E+03	8.9E+03	2.9E+09	3.6E+09
SD-CIF	1.7E-06	1.8E+00	2.6E+00	95	8.3E+02	8.8E+02	2.2E+04	2.2E+04	7.1E+09	8.3E+09
SD-COPEN-RCSINTACT	2.7E-07	7.1E+00	7.1E+01	2	1.8E+03	3.2E+03	1.8E+05	3.5E+05	3.1E+10	5.9E+10
SD-COPEN-RCSVENT	1.3E-07	2.2E+01	1.3E+02	2	2.3E+03	6.7E+03	2.6E+05	7.2E+05	4.7E+10	1.3E+11
SD-COPEN-HEADOFF	7.8E-08	2.4E+01	4.5E+01	52	2.8E+03	7.5E+03	2.0E+05	4.7E+05	4.2E+10	1.1E+11
SD-ECF	5.1E-10	3.0E-01	1.6E+00	~64	1.0E+02	1.0E+02	8.3E+03	8.3E+03	1.5E+09	1.9E+09
SD-CF-Before-CD	2.1E-06	4.2E+00	6.1E+00	103	1.6E+03	2.3E+03	7.3E+04	8.0E+04	1.8E+10	2.3E+10
SD-ICF-BURN	1.7E-06	1.6E-01	1.4E+00	~85	4.3E+01	4.3E+01	1.7E+04	1.8E+04	2.3E+09	2.5E+09
SD-LCF	5.5E-08	5.2E-04	2.0E-03	>156	1.7E-01	1.7E-01	5.0E-01	5.0E-01	3.2E+07	3.2E+07
SD-BMT	1.2E-07	4.7E-05	5.2E-04	>140	8.8E-06	8.8E-06	-	-	2.5E+07	2.5E+07
SD-NOCF	6.1E-06	2.6E-04	1.4E-04	>138	8.3E-02	8.3E-02	-	-	3.1E+07	3.1E+07

1. Frequency values were taken from Table 2-74 of NRC (2025).

2. Results are a frequency-weighted sum of all release categories.

Note: Dashes represent MACCS results that are identically zero.

In addition to the base case results summarized in Table 4-1 through Table 4-4 and discussed in more detail in Sections 4.1 through 4.6, selected sensitivity analyses were run to examine the impact on offsite consequences of certain project assumptions. The three sensitivity cases correspond to sensitivity case ME_2 (meteorological sampling), sensitivity case RE_4 (accident truncation time), and sensitivity case HE_2 (use of a dose truncation level for cancer risk estimation corresponding to the 2010 HPS position paper on radiation risk).

The meteorological sampling sensitivity case ME_2 examined the effect of sampling only a subset of weather trials, which has been typical practice for consequence analyses. The weather bins and number of weather trials sampled per bin were based on the INWGHT (SUBSET) column of Table 3.2-10 of NRC (2022a). The number of samples per weather bin used in sensitivity case ME_2 reflect the sampling approach defined in the SOARCA analyses. Execution of this sensitivity case also provided a reference comparison case for running sensitivity cases RE_4 and HE_2 using a smaller weather sample, which provides for increased computational efficiency for these more complex sensitivity analyses.

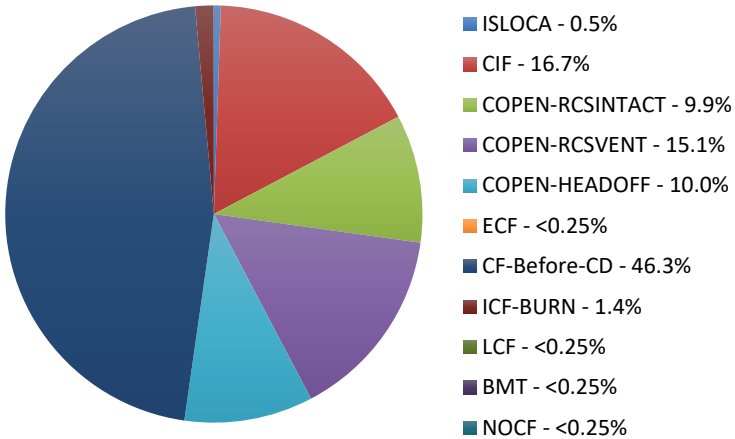
As discussed in Section 2.6.3.15 of NRC (2025), there is significant uncertainty regarding the severe accident sequence termination time. As such, environmental radiological release results are provided in the Level 2 PRA report for three different accident termination times (36 hours after SAMG entry, 60 hours after SAMG entry, and 7 days after accident initiation). The base case results for the Level 3 PRA are based on an accident termination time of 7 days after accident initiation. To gain insight into the range of consequence/risk results from different accident termination times, sensitivity case RE_4 allowed examination of the potential impact of terminating radiological releases from all the representative accident sequences 36 hours after SAMG entry. The conditions for initiating the need for SAMGs are indications that fuel clad has failed and core melt is imminent or occurring, which are indications of readouts of 649°C (1,200°F) on core exit thermocouples. For sensitivity case RE_4, accident releases from MELCOR were truncated 36 hours after the time at which core exit thermocouple temperature was projected to exceed 649°C (1,200°F). A significant impact of terminating radiological releases 36 hours after SAMG entry is a reduction in the amount of radioactivity released. This is illustrated in Table 4-5 (showing the impact of the accident termination time on the cumulative release fractions for all chemical groups) and Figure 4-1 (showing the impact of accident termination time on the relative contribution of release categories to the frequency-weighted cumulative cesium release fraction). As evident from Table 4-5, the degree of reduction of radioactivity released is a function of both the release category and the chemical group. It can be seen in Table 4-5 that the cumulative cesium release from the ECF and ICF-BURN release categories are most affected by the accident termination time, with the total cesium release being reduced by over 99 percent. As a result, the relative contribution of release categories to the frequency-weighted cumulative cesium release fraction changes (albeit slightly), as seen in Figure 4-1.

Table 4-5 Truncated Cumulative Release Fractions at 36 Hours after SAMG Entry (RE_4) Compared to Untruncated Cumulative Release Fractions (ME_2)

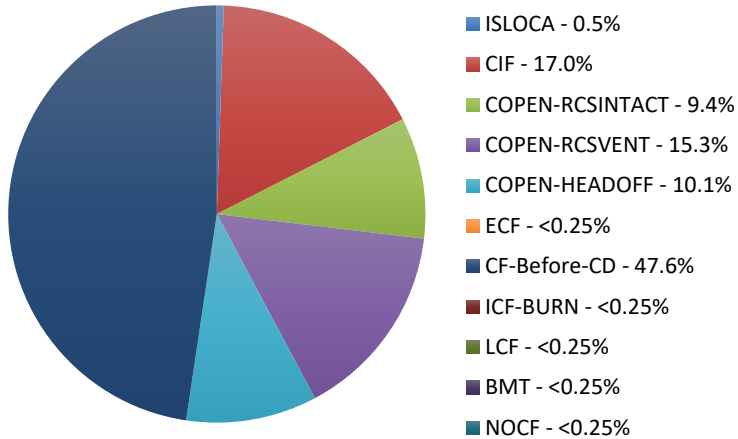
Release Category		Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
	LPSD-RE_4	9.4E-01	2.7E-02	5.5E-04	4.0E-02	3.7E-02	6.9E-04	6.5E-03	5.5E-07	3.7E-08
	LPSD-ME_2	9.9E-01	2.8E-02	6.3E-04	4.5E-02	4.4E-02	7.0E-04	9.6E-03	6.2E-07	1.1E-07
SD-ISLOCA	% Truncated	5.2%	3.3%	13.1%	11.3%	16.3%	0.1%	33.0%	11.8%	66.4%
	LPSD-RE_4	6.0E-01	6.6E-02	1.2E-03	5.7E-02	5.3E-02	1.3E-03	1.4E-02	3.0E-06	2.5E-07
	LPSD-ME_2	6.7E-01	6.7E-02	1.2E-03	5.9E-02	5.3E-02	1.3E-03	1.4E-02	3.1E-06	3.2E-07
SD-CIF	% Truncated	10.6%	1.1%	0.2%	3.1%	1.0%	0.1%	0.9%	2.6%	21.0%
	LPSD-RE_4	1.0E+00	2.3E-01	1.7E-02	3.8E-01	2.3E-01	1.1E-03	2.7E-02	3.7E-04	1.5E-05
	LPSD-ME_2	1.0E+00	2.5E-01	1.8E-02	3.8E-01	3.4E-01	1.1E-03	6.4E-01	3.8E-04	2.3E-05
SD-COPEN-RCSINTACT	% Truncated	0.0%	6.6%	8.6%	1.5%	30.9%	1.0%	95.8%	2.4%	36.8%
	LPSD-RE_4	1.0E+00	7.8E-01	7.2E-02	8.1E-01	8.0E-01	2.6E-02	1.9E-01	8.3E-03	1.7E-04
	LPSD-ME_2	1.0E+00	7.9E-01	7.5E-02	8.2E-01	8.2E-01	2.6E-02	7.6E-01	8.3E-03	1.8E-04
SD-COPEN-RCSVENT	% Truncated	0.0%	0.7%	4.2%	0.4%	2.3%	0.1%	74.8%	0.2%	4.6%
	LPSD-RE_4	1.0E+00	8.6E-01	2.1E-02	8.6E-01	7.8E-01	1.8E-02	2.0E-01	1.6E-04	7.9E-06
	LPSD-ME_2	1.0E+00	8.7E-01	2.2E-02	8.8E-01	8.0E-01	1.8E-02	2.0E-01	1.6E-04	1.0E-05
SD-COPEN-HEADOFF	% Truncated	0.0%	0.6%	1.6%	1.9%	2.0%	0.0%	0.0%	1.6%	24.1%
	LPSD-RE_4	3.4E-01	1.1E-04	1.5E-05	5.3E-04	3.2E-04	4.7E-07	6.8E-06	6.3E-07	1.8E-07
	LPSD-ME_2	9.5E-01	1.1E-02	1.8E-04	3.0E-02	3.4E-03	8.7E-07	6.0E-02	1.5E-06	8.7E-07
SD-ECF	% Truncated	64.4%	99.0%	91.5%	98.2%	90.5%	46.2%	100.0%	57.4%	79.0%
	LPSD-RE_4	9.2E-01	1.5E-01	2.8E-03	1.4E-01	1.2E-01	2.7E-03	2.9E-02	2.0E-05	8.6E-07
	LPSD-ME_2	9.5E-01	1.5E-01	2.8E-03	1.4E-01	1.2E-01	2.7E-03	2.9E-02	2.0E-05	9.0E-07
SD-CF-Before-CD	% Truncated	3.2%	0.3%	0.1%	1.0%	0.3%	0.0%	0.3%	0.4%	5.0%
	LPSD-RE_4	2.0E-03	1.1E-05	1.1E-06	1.1E-05	1.0E-05	3.0E-07	2.6E-06	1.1E-07	2.2E-09
	LPSD-ME_2	1.0E+00	5.7E-03	1.0E-03	2.7E-02	7.3E-03	8.1E-07	1.0E-01	2.7E-06	2.4E-06
SD-ICF-BURN	% Truncated	99.8%	99.8%	99.9%	100.0%	99.9%	62.8%	100.0%	95.8%	99.9%
	LPSD-RE_4	2.4E-03	1.2E-05	4.1E-07	1.3E-05	1.1E-05	3.1E-07	2.8E-06	1.0E-07	1.4E-08
	LPSD-ME_2	1.4E-02	1.8E-05	1.6E-06	1.7E-05	2.4E-05	3.1E-07	1.8E-04	1.0E-07	1.7E-08
SD-LCF	% Truncated	83.3%	37.2%	74.7%	27.6%	52.9%	0.1%	98.4%	3.3%	18.7%

Table 4-5 Truncated Cumulative Release Fractions at 36 Hours after SAMG Entry (RE_4) Compared to Untruncated Cumulative Release Fractions (ME_2) (cont.)

Release Category		Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
	LPSD-RE_4	1.6E-03	1.5E-06	1.4E-07	2.2E-06	2.0E-06	1.6E-08	3.1E-07	1.5E-08	3.3E-10
	LPSD-ME_2	8.6E-03	1.7E-06	2.0E-07	2.6E-06	3.6E-06	1.6E-08	2.9E-06	1.5E-08	4.9E-10
SD-BMT	% Truncated	81.9%	9.2%	31.4%	15.3%	44.6%	0.0%	89.4%	1.1%	33.3%
	LPSD-RE_4	8.5E-04	1.7E-05	4.4E-07	1.5E-05	1.4E-05	3.1E-07	3.9E-06	3.9E-09	1.3E-10
	LPSD-ME_2	3.2E-03	1.8E-05	5.3E-07	1.9E-05	1.8E-05	3.1E-07	4.3E-06	5.3E-09	1.1E-09
SD-NOCF	% Truncated	73.3%	10.4%	18.0%	22.5%	22.4%	0.4%	9.4%	26.9%	87.7%



Base Case



RE_4

Figure 4-1 Relative Contribution of Release Categories to Frequency-Weighted Cumulative Cesium Release Fraction: Base Case vs. RE_4

Sensitivity case HE_2 allowed examination of the cancer risks arising only from moderate or high doses, where the level of uncertainty in cancer risk estimation is less than in the low and very low dose range. This was implemented using a model that estimates cancer risk based only on annual individual doses greater than 0.05 Sv (5 rem), or lifetime individual doses greater than 0.1 Sv (10 rem). This sensitivity case allowed examination of how much of the projected cancer risk arises from exposures in the low or very low dose range, where cancer risk modeling is more uncertain than in the moderate or high dose range.

In each of the following subsections, the impact of each of these three sensitivity cases on the different consequence measures selected for tabulation is discussed.

4.1 Doses to the Offsite Public

The following discussion is adapted from Section 4.1 of NRC (2022a) and is modified to discuss the effect of the different release category characteristics associated with the LPSD analysis documented in NRC (2025). The dosimetric measure selected for risk integration in the Level 3 PRA project includes the collective total effective dose from both acute and chronic exposure. This value was computed using the MACCS Type 5 output and the MACCS L-ICRP60ED dosimetric quantity. Collective effective dose arises from both direct exposure pathways (i.e., groundshine, cloudshine, cloud inhalation, and resuspension inhalation) and collective late-phase indirect exposure pathways (i.e., food and water consumption). Values for the collective total effective dose were tabulated at 50 and 100 miles.

Several intermediate dosimetric results were examined to assist in interpretation of the collective total effective dose. The size of population with early-phase doses above the low dose range, that is, greater than 10 rem total effective dose or greater than 10 rad-eq acute dose to the red bone marrow (quantified using the MACCS A-RED MARR dosimetric quantity) was examined using the MACCS Type 3 output (Population Exceeding a Dose Threshold). Table 4-6 shows the size of the population exceeding an early-phase total effective dose of 10 rem or an early-phase acute dose to the red bone marrow of 10 rad-equivalent. The frequency of each release category and the total cesium and iodine release (in MCi) is also provided for context. The potential for moderate or high doses is largely associated with events with large releases and open containments (e.g., COPEN-RCSVENT, COPEN-HEADOFF, and, to a lesser extent, COPEN-RCSINTACT). It may be noted that there can be a significant difference (up to several orders of magnitude) between the size of the population receiving moderate effective doses and moderate acute red bone marrow doses. The size of the population expected to receive moderate or high acute doses is very small (on average, much less than a single individual[7]).

Inspection of the peak doses (computed using the MACCS Type A output) as a function of distance from the site for the non-evacuating cohort and the late-phase cohort is shown in Figure 4-2 and Figure 4-3 (showing the mean peak dose) and Figure 4-4 and Figure 4-5 (showing the probability exceeding specified dose levels). High (>100 rem) effective doses are, on average, limited to within 10 miles from the site, even for the non-evacuating cohort who may

[7] Values of less than a single person may occur as the result of weighting small populations by low values, usually arising from the combination of low values for the likelihood of being in a specific cohort and relatively infrequent weather conditions. For example, in a hypothetical example of a population of 100 persons, if there is a 0.5 percent chance of non-evacuation, and the combination of wind direction and meteorological conditions places that population at risk of elevated exposure for less than 10 percent of all weather samples, that population would be reported as a value of 0.05 persons.

receive exposures in the most contaminated areas for up to 12 hours. Moderate (>10 rem) committed doses are limited, on average, to within 25 miles of the site. Consistent with the Type 3 results, the highest doses arise from events with large releases and open containments (e.g., COPEN-RCSVENT. COPEN-HEADOFF and, to a lesser extent, COPEN-RCSINTACT). It may be noted that two release categories (ICF-BURN and ECF) display pattern of dose and distance different from all other release categories, with the early-phase dose to the non-evacuating cohort relatively flat, with a value on the order of 1 rem, out to approximately 20 miles. These are the release categories that are characterized by a prolonged period of low initial release, as discussed in Section 3.4.2.4.1 and shown in Figure 3-5 and Figure 3-6. The dose plateau near the site is likely the result of a relocation time that can remove the non-evacuating population before much of the dose has been accumulated. This may be the reason that the ICF-BURN release category, despite having a relatively large release of iodine, does not result in elevated early-phase doses. In contrast, doses incurred during the recovery phase are low near the site but decline more slowly with distance from the site for the most severe scenarios. This is most likely because of long-term protective actions, which are assumed to limit individual doses in the intermediate and recovery phases to levels below the habitability criteria, leading to low (<10 rem) lifetime doses.

Table 4-6 Summary of Population Exceeding Dose (Conditional Mean Value Across All Weather Trials)

Release Category	Freq[1] (/yr)	Cumul. Cesium Release (MCi)	Cumul. Iodine Release (MCi)	Warning Time (hr)	Population Exceeding Early-Phase Total Effective Dose of 10 rem (persons)[3]	Population Exceeding Early-Phase Acute Red Bone Marrow Dose of 10 rad-eq (persons)[3]
All[2] (per yr)	1.2E-05	1.9E-05	6.0E-05		5.4E-04	3.3E-07
ISLOCA	1.3E-07	8.0E-01	8.3E+00	7	1.2E-01	4.0E-03
CIF	1.7E-06	1.8E+00	2.6E+00	>>24	3.7E-02	1.2E-04
COPEN-RCSINTACT	2.7E-07	7.1E+00	7.1E+01	2	1.6E+01	8.2E-02
COPEN-RCSVENT	1.3E-07	2.2E+01	1.3E+02	~7	3.6E+03	2.2E+00
COPEN-HEADOFF	7.8E-08	2.4E+01	4.5E+01	>>24	8.8E+02	1.9E-01
ECF	5.1E-10	3.0E-01	1.6E+00	N/A	-	-
CF-Before-CD	2.1E-06	4.2E+00	6.1E+00	>>24	2.4E-01	3.0E-03
ICF-BURN	1.7E-06	1.6E-01	1.4E+00	>>24	2.0E-06	-
LCF	5.5E-08	5.2E-04	2.0E-03	>>24	-	-
BMT	1.2E-07	4.7E-05	5.2E-04	>>24	-	-
NOCF	6.1E-06	2.6E-04	1.4E-04	>>24	-	-

Source: adapted from Table 4-1

1. Frequency values were taken from Table 2-74 of NRC (2025).

2. Results are a frequency-weighted sum of all release categories.

3. Results are integrated across the entire modeling domain.

Note: Dashes represent MACCS results that are identically zero.

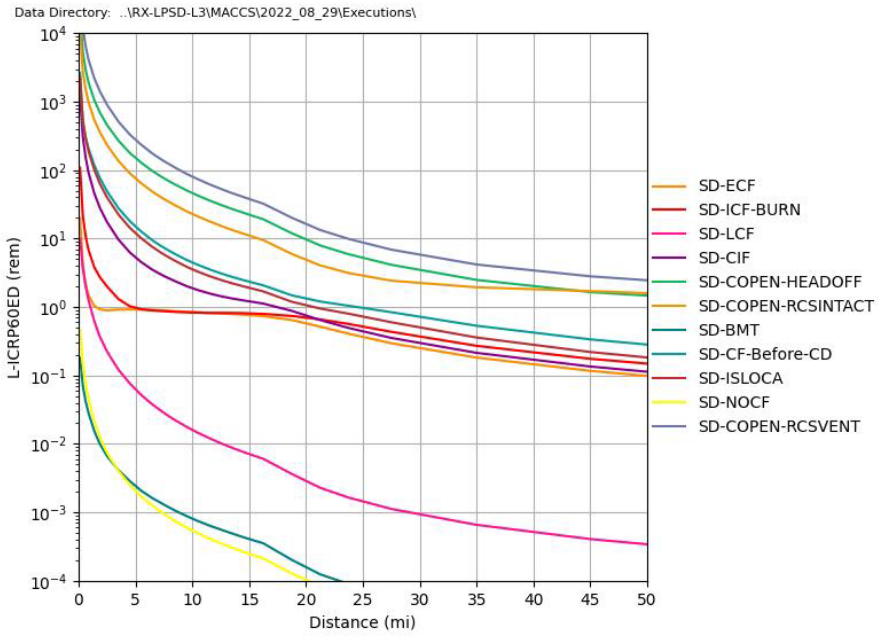


Figure 4-2 Conditional Mean Value (Across All Weather Trials) of Peak Total Effective Dose (rem) from Early-Phase Exposure to the Non-Evacuating Cohort

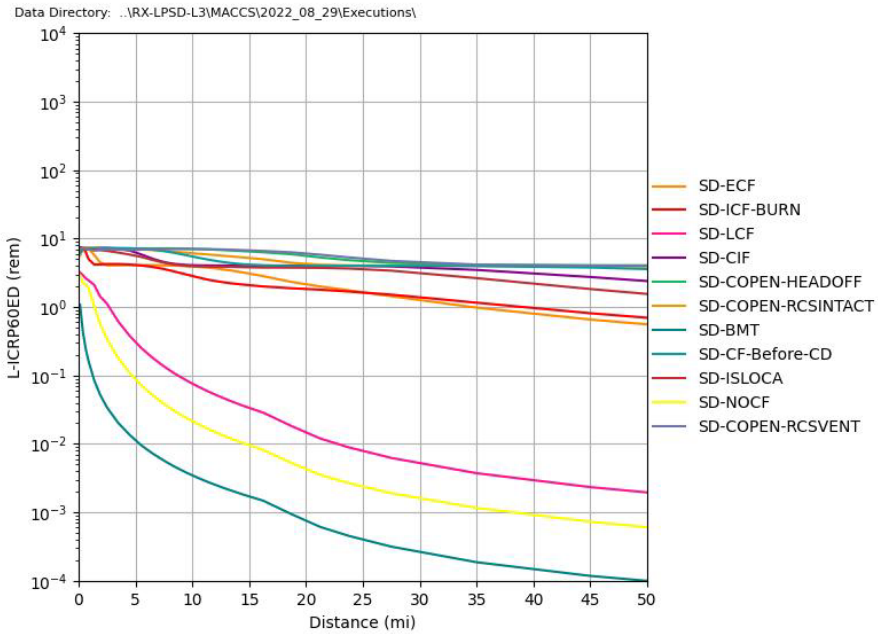


Figure 4-3 Conditional Mean Value (Across All Weather Trials) of Peak Total Effective Dose (rem) from Late-Phase Exposure

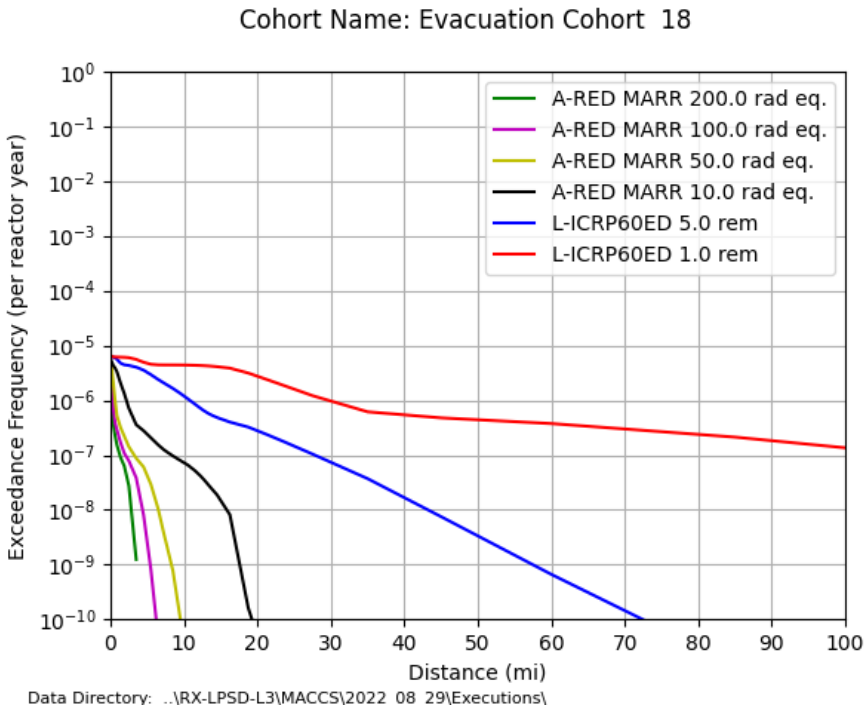


Figure 4-4 Annual Frequency of Exceeding a Specified Dose Level (rem/rad-eq) from Early-Phase Exposure to the Non-Evacuating Cohort

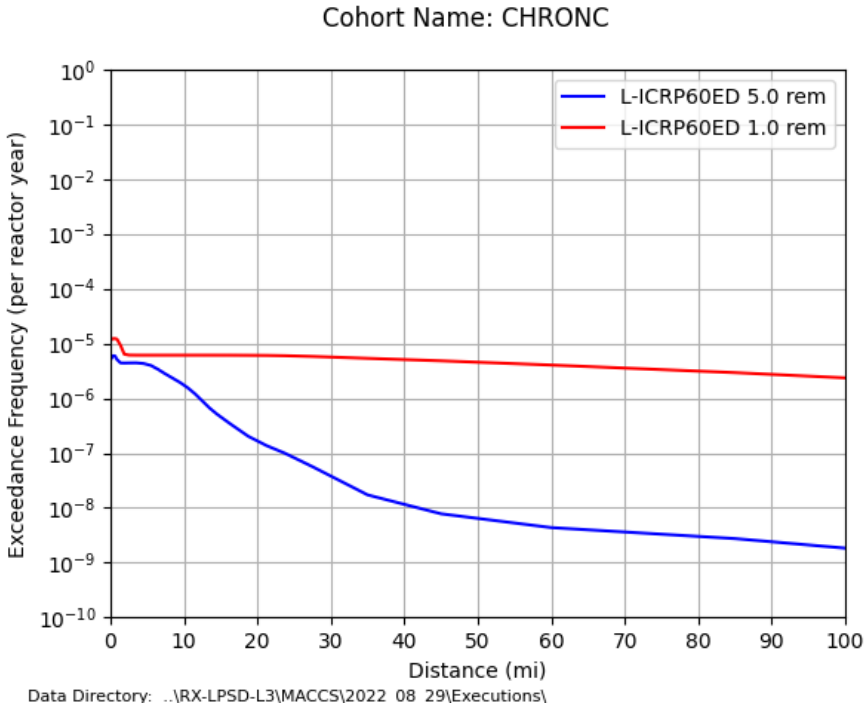


Figure 4-5 Annual Frequency of Exceeding a Specified Dose Level (rem) from Late-Phase Exposure

The preceding discussion provides an indication of how doses are distributed in the offsite population. However, the value selected for tabulation in the Level 3 PRA project is the collective total effective dose. The collective total effective doses were examined using the MACCS Type 5 output, which provides the total long-term population dose to a given organ resulting from the contamination of a specified region. This output takes full account of the population and its distribution, such that larger population cohorts characterized by lower exposures may exhibit higher overall collective doses. The combined results for early and late-phase cohorts are provided in Table 4-7. The breakdown of the collective dose by release category and cohort type is shown in Table 4-8 and Table 4-9. The results are given by types of cohorts as well as overall to evaluate which populations are at risk. The non-evacuating cohort includes those within the evacuation zone who do not evacuate when ordered to do so, as well as those outside of the evacuation zone. Therefore, the reported results for this cohort have been divided into those inside the largest mandatory evacuation zone (<20 mi) and those outside the largest mandatory evacuation zone (>20 mi).[8] Examination of Table 4-7, Table 4-8, and Table 4-9 shows that over 90 percent of the collective total effective dose at distances of 50 miles or greater is associated with the combination of the late-phase exposures represented by the CHRONC cohort and the early-phase exposures to the non-evacuating individuals beyond the 20-mile maximum evacuation zone. Both cohorts are characterized by low (<10 rem) total effective doses to individuals, as seen in Figure 4-2 through Figure 4-5.

Table 4-7 Summary of Collective Total Effective Dose (Conditional Mean Value Across All Weather Trials)

Release Category	Freq[1] (/yr)	Cumul. Cesium Release (MCi)	Cumul. Iodine Release (MCi)	Warning Time (hr)	Collective Total Effective Dose (person-rem)	
					0–50 miles	0–100 miles
All[2] (per yr)	1.2E-05	1.9E-05	6.0E-05		3.6E+00	8.9E+00
ISLOCA	1.3E-07	8.0E-01	8.3E+00	7	2.9E+05	5.9E+05
CIF	1.7E-06	1.8E+00	2.6E+00	>>24	5.7E+05	1.2E+06
COPEN-RCSINTACT	2.7E-07	7.1E+00	7.1E+01	2	1.1E+06	3.4E+06
COPEN-RCSVENT	1.3E-07	2.2E+01	1.3E+02	~7	1.4E+06	4.6E+06
COPEN-HEADOFF	7.8E-08	2.4E+01	4.5E+01	>>24	1.4E+06	4.4E+06
ECF	5.1E-10	3.0E-01	1.6E+00	N/A	2.4E+05	4.5E+05
CF-Before-CD	2.1E-06	4.2E+00	6.1E+00	>>24	7.7E+05	2.0E+06
ICF-BURN	1.7E-06	1.6E-01	1.4E+00	>>24	2.2E+05	4.5E+05
LCF	5.5E-08	5.2E-04	2.0E-03	>>24	1.6E+03	2.3E+03
BMT	1.2E-07	4.7E-05	5.2E-04	>>24	1.0E+02	1.5E+02
NOCF	6.1E-06	2.6E-04	1.4E-04	>>24	5.9E+02	8.1E+02

Source: adapted from Table 4-1

1. Frequency values were taken from Table 2-74 of NRC (2025).

2. Results are a frequency-weighted sum of all release categories.

3. Results are integrated across the entire modeling domain.

[8] As discussed in Section 3.4.2.3.1, the actual evacuation zone size is source-term-dependent and can range from 10 miles (EP Model 1) to 20 miles (EP Model 3). For simplicity, the results in Table 4-7, Table 4-8, and Table 4-9 provide only the results inside 20 miles and outside of 20 miles as a surrogate for non-evacuees within the evacuation zone and non-evacuees outside of the evacuation zone.

Table 4-8 Conditional Mean (Across All Weather Trials) Collective Total Effective Dose (Person-Rem) by Cohort Type within 50 Miles

Release Category	EVAC	SCH	SHADOW	IND	NON-EVAC (<20 MI)	NON-EVAC (>20 MI)	CHRONC	OVERALL
ISLOCA	450	-	0.01	-	36	33000	260000	290000
CIF	360	-	3.2	-	30	25000	540000	570000
COPEN-RCSINTACT	3900	-	34	520	220	250000	840000	1100000
COPEN-RCSVENT	28000	-	670	980	620	480000	930000	1400000
COPEN-HEADOFF	16000	-	330	-	370	290000	1100000	1400000
ECF	0.99	-	0.18	0.00002	18	22000	210000	240000
CF-Before-CD	27	-	-	-	58	58000	710000	770000
ICF-BURN	3.4	-	0.35	4.6E-06	20	30000	190000	220000
LCF	0.00035	-	-	0.000017	390	-310	1500	1600
BMT	0.0063	-	0.00043	0.016	35	-29	95	100
NOCF	0.039	-	0.0059	0.033	210	-200	590	590

Notes:

1. *EVAC refers to the sum of all 12 evacuating cohorts (4 cohorts each for 0–10, 10–15, and 15–20 miles). NON-EVAC refers to the non-evacuating cohort, subdivided into those inside the mandatory evacuation zone (<20 mi)) and those outside the evacuation zone (>20 mi). SCH refers to the schools cohort, if modeled. SHADOW refers to the 20 percent of the population immediately outside of the evacuation zone that voluntarily evacuates. iND refers to the restricted access industrial facility employees. CHRONC refers to the exposure arising after the late (recovery) phase has ended. OVERALL refers to the combined set of all cohorts.*
2. *Non-evacuating cohort results are given for 0–10 miles and 10–50 miles because only a 10-mile evacuation zone was modeled.*
3. *Dashes represent MACCS results that are identically zero.*

Table 4-9 Conditional Mean (Across All Weather Trials) Collective Total Effective Dose (Person-Rem) by Cohort Type within 100 Miles

Release Category	EVAC	SCH	SHADOW	IND	NON-EVAC (<20 MI)	NON-EVAC (>20 MI)	CHRONC	OVERALL
ISLOCA	450	-	0.01	-	36	63000	530000	590000
CIF	360	-	3.2	-	30	48000	1100000	1200000
COPEN-RCSINTACT	3900	-	34	520	220	700000	2700000	3400000
COPEN-RCSVENT	28000	-	670	980	620	1200000	3400000	4600000
COPEN-HEADOFF	16000	-	330	-	370	660000	3700000	4400000
ECF	0.99	-	0.18	0.00002	18	43000	410000	450000
CF-Before-CD	27	-	-	-	58	110000	1900000	2000000
ICF-BURN	3.4	-	0.35	4.6E-06	20	60000	390000	450000
LCF	0.00035	-	-	0.000017	0.039	130	2200	2300
BMT	0.0063	-	0.00043	0.016	0.0022	12	140	150
NOCF	0.039	-	0.0059	0.033	0.0018	5.8	800	810

Notes:

1. *EVAC refers to the sum of all 12 evacuating cohorts (4 cohorts each for 0–10, 10–15, and 15–20 miles). NON-EVAC refers to the non-evacuating cohort, subdivided into those inside the mandatory evacuation zone (<20 mi)) and those outside the evacuation zone (>20 mi). SCH refers to the schools cohort, if modeled. SHADOW refers to the 20 percent of the population immediately outside of the evacuation zone that voluntarily evacuates. iND refers to the restricted access industrial facility employees. CHRONC refers to the exposure arising after the late (recovery) phase has ended. OVERALL refers to the combined set of all cohorts.*
2. *Non-evacuating cohort results are given for 0–10 miles and 10–50 miles because only a 10-mile evacuation zone was modeled.*
3. *Dashes represent MACCS results that are identically zero.*

The contribution of individual release categories to the mean collective effective dose is shown in Figure 4-6 and Figure 4-7. In contrast to the events driving the potential for moderate-to-high doses, which are the low-frequency large releases, collective effective doses within 50 or 100 miles are dominated by the more likely large releases from intermediate containment failures, containment isolation failures, or containment failures before core damage. The relative contributions from the different release categories to collective total effective dose is like the relative contributions from the different release categories to total radionuclide release shown in Figure 3-1 and Figure 3-2, with a few notable exceptions. For example, the ICF-BURN release category contributes about 1 percent of the frequency-weighted cesium release but about 10 percent of the frequency-weighted collective effective dose. This may be due to constraining effects of long-term protective actions on collective effective dose, which may result in a sublinear dependence of collective effective dose on the amount of cesium released. This potential effect is illustrated in Figure 4-8, showing the collective total effective dose as a function of the cesium release magnitude.

The previous discussions have focused on the mean values. The CCDF provides information on the variability of the results because of weather conditions and different release categories. The CCDF curves for collective effective dose, for 0–50 miles and 0–100 miles, are shown in Figure 4-9 and Figure 4-10, respectively. Release categories CF-Before-CD, CIF, and ICF-BURN appear to be the main contributors to collective effective dose within 50 miles, particularly at the higher frequencies. This is consistent with the observations drawn from Figure 4-6 and Figure 4-7. At lower frequencies, the effect of the COPEN-RCSVENT release category become more noticeable, which is the dominant release category for collective effective doses greater than approximately 3×10^{-6} person-rem within 50 miles.

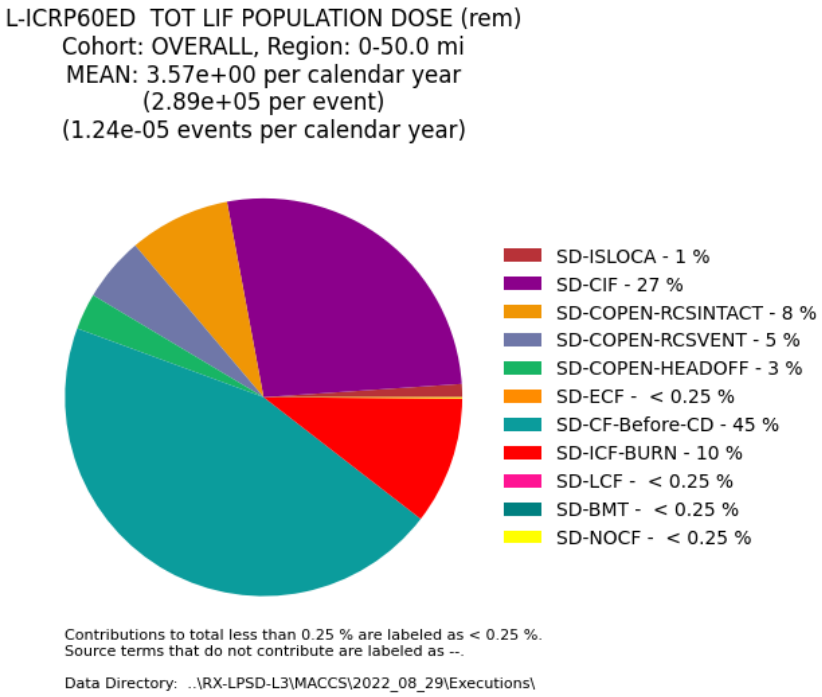


Figure 4-6 Relative Contribution of Release Categories to Mean (Over All Weather Trials) Collective Total Effective Dose, Overall, 50 Miles

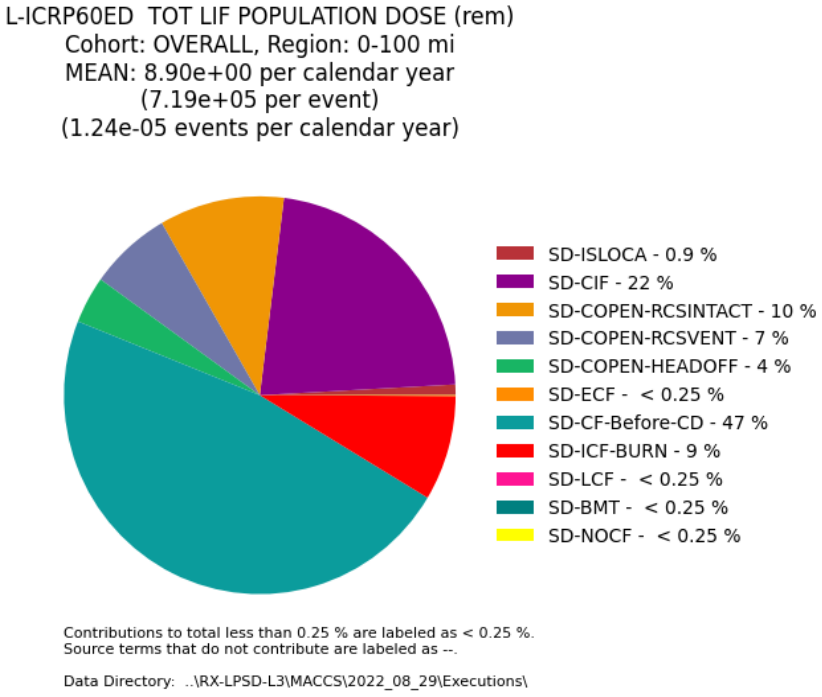


Figure 4-7 Relative Contribution of Release Categories to Mean (Over All Weather Trials) Collective Total Effective Dose, Overall, 100 Miles

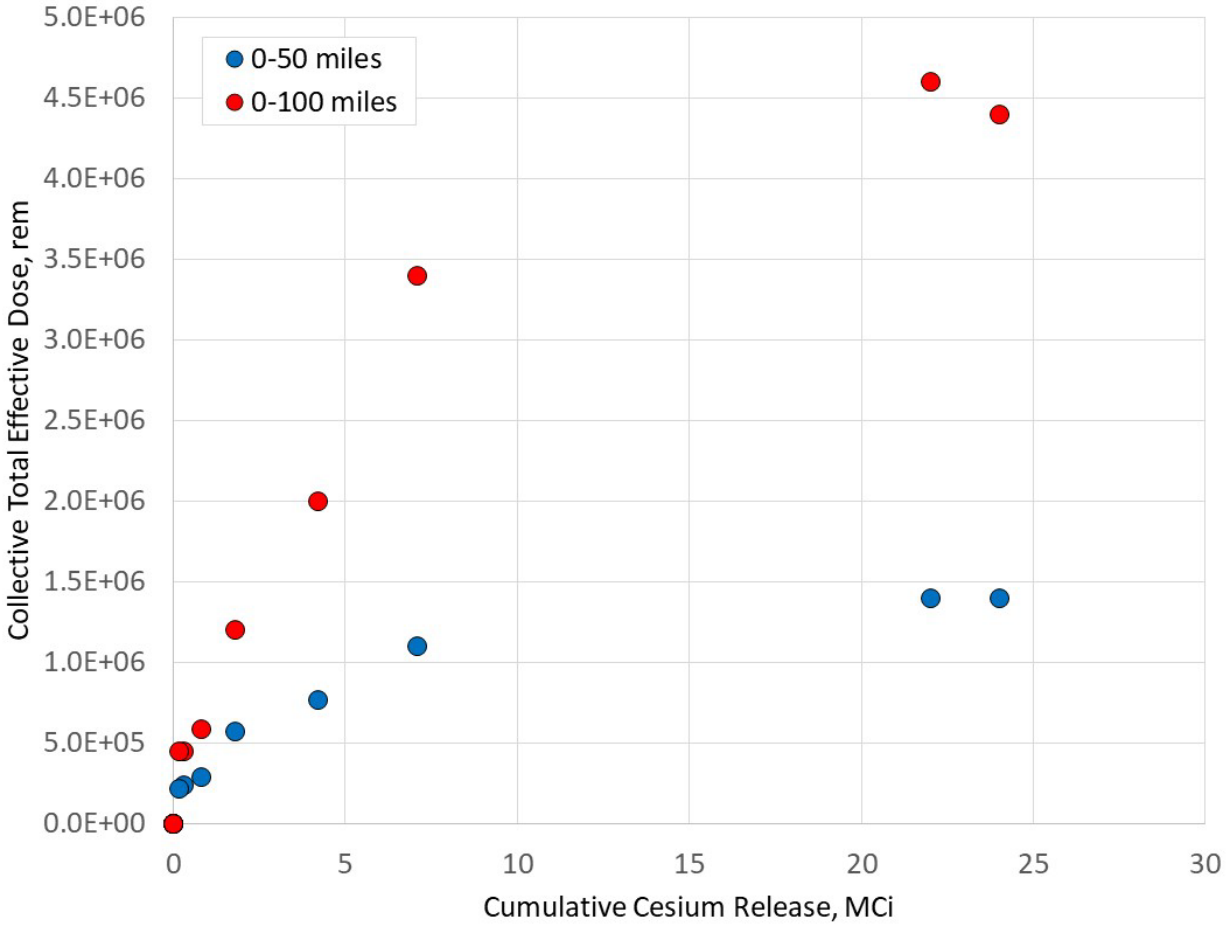


Figure 4-8 Conditional Mean (Across All Weather Trials) Collective Total Effective Dose within 50 and 100 Miles as a Function of Cesium Release Magnitude

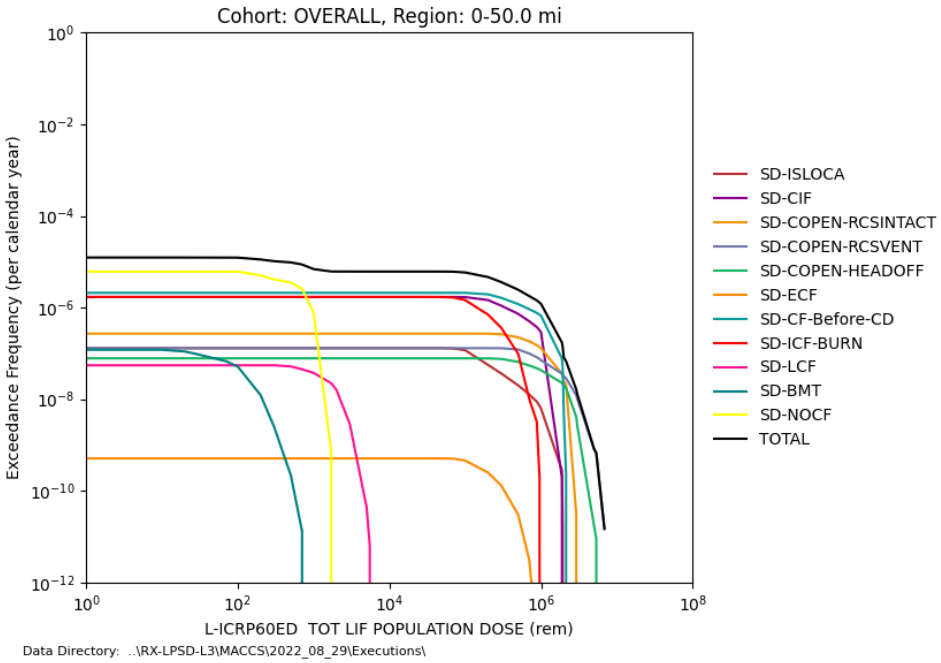


Figure 4-9 Complementary Cumulative Distribution Function of Collective Total Effective Dose, 0–50 Miles (person-rem)

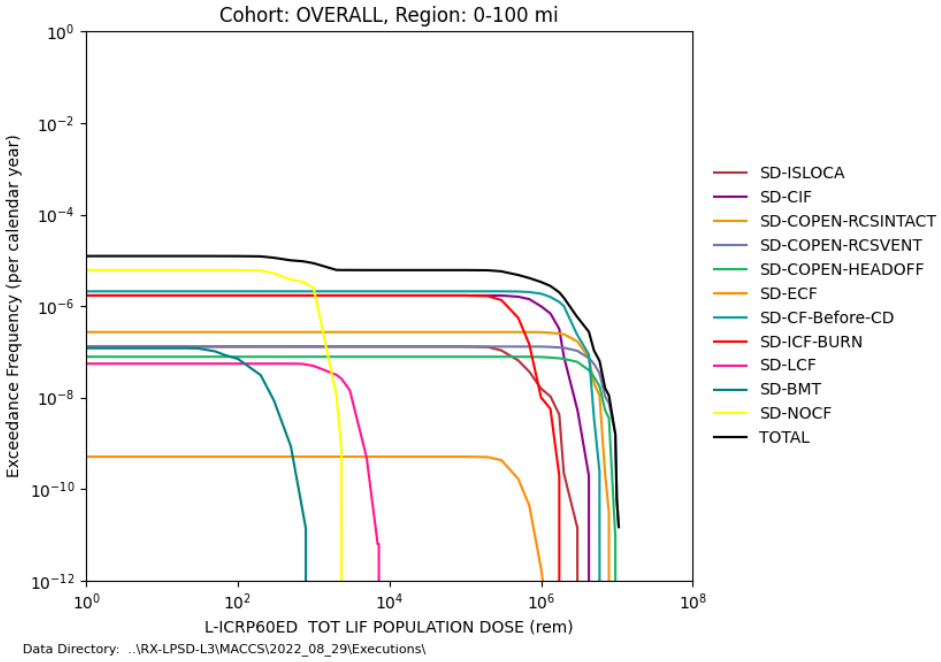


Figure 4-10 Complementary Cumulative Distribution Function of Collective Total Effective Dose, 0–100 Miles (person-rem)

4.1.1 Sensitivity Cases

4.1.1.1 Meteorological Sampling

The effect of sampling only a subset of the meteorological data on the collective effective dose within 80 and 161 km (50 and 100 mi) is demonstrated in Table 4-10 and Table 4-11, respectively. It is evident from inspection of these results that differences resulting from sampling a representative subset of weather trials as opposed to sampling all 8,760 hourly observations are generally less than a few percent.

The effect of sampling only a subset of the meteorological data on the population exceeding an early-phase total effective dose of 0.1 Sv (10 rem) is shown in Table 4-12. The effect of sampling only a subset of the meteorological data on the population exceeding an early-phase acute red bone marrow dose of 0.1 Gy-eq (10 rad-eq) (persons) is shown in Table 4-13. The sensitivity of these metrics, which represent the small subset of the population that may receive elevated doses, is greater than the sensitivity of the collective effective dose to weather sampling. The overall frequency weighted results can vary by on the order of 20 percent, and the effect on individual release categories can vary between a factor of 0.3 to 1.3.

Table 4-10 Conditional Mean (Across All Weather Trials) Collective Total Effective Dose (Person-Rem), 0–50 Miles: ME_2

Release Category	Frequency (/yr)	Base Case	ME_2	Fraction of Base Case[2]
ALL[1] (per yr)	**1.2E-05**	**3.6E+00**	**3.5E+00**	**0.981**
ISLOCA	1.3E-07	2.9E+05	2.9E+05	0.980
CIF	1.7E-06	5.7E+05	5.5E+05	0.979
COPEN-RCSINTACT	2.7E-07	1.1E+06	1.1E+06	0.982
COPEN-RCSVENT	1.3E-07	1.4E+06	1.4E+06	0.993
COPEN-HEADOFF	7.8E-08	1.4E+06	1.4E+06	1.000
ECF	5.1E-10	2.4E+05	2.4E+05	1.008
CF-Before-CD	2.1E-06	7.7E+05	7.5E+05	0.970
ICF-BURN	1.7E-06	2.2E+05	2.2E+05	1.023
LCF	5.5E-08	1.6E+03	1.6E+03	1.006
BMT	1.2E-07	1.0E+02	1.0E+02	0.990
NOCF	6.1E-06	5.9E+02	6.0E+02	1.010

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of base case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded base case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Table 4-11 Conditional Mean (Across All Weather Trials) Collective Total Effective Dose (Person-Rem), 0–100 Miles: ME_2

Release Category	Frequency (/yr)	Base Case	ME_2	Fraction of Base Case[2]
ALL[1] (per yr)	**1.2E-05**	**8.9E+00**	**8.8E+00**	**0.993**
ISLOCA	1.3E-07	5.9E+05	5.9E+05	0.997
CIF	1.7E-06	1.2E+06	1.2E+06	1.000
COPEN-RCSINTACT	2.7E-07	3.4E+06	3.4E+06	0.997
COPEN-RCSVENT	1.3E-07	4.6E+06	4.6E+06	1.000
COPEN-HEADOFF	7.8E-08	4.4E+06	4.4E+06	1.000
ECF	5.1E-10	4.5E+05	4.6E+05	1.002
CF-Before-CD	2.1E-06	2.0E+06	2.0E+06	0.985
ICF-BURN	1.7E-06	4.5E+05	4.5E+05	1.000
LCF	5.5E-08	2.3E+03	2.3E+03	1.009
BMT	1.2E-07	1.5E+02	1.5E+02	1.000
NOCF	6.1E-06	8.1E+02	8.1E+02	1.010

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of base case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded base case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Table 4-12 Conditional Mean (Across All Weather Trials) Population Exceeding Early-Phase Total Effective Dose of 10 Rem (Persons): ME_2

Release Category	Frequency (/yr)	Base Case[2]	ME_2[2]	Fraction of Base Case[3]
ALL[1] (per yr)	**1.2E-05**	**5.4E-04**	**6.3E-04**	**1.168**
ISLOCA	1.3E-07	1.2E-01	1.1E-01	0.926
CIF	1.7E-06	3.7E-02	3.6E-02	0.968
COPEN-RCSINTACT	2.7E-07	1.6E+01	1.3E+01	0.858
COPEN-RCSVENT	1.3E-07	3.6E+03	4.2E+03	1.158
COPEN-HEADOFF	7.8E-08	8.8E+02	1.1E+03	1.254
ECF	5.1E-10	-	-	-
CF-Before-CD	2.1E-06	2.4E-01	2.4E-01	0.987
ICF-BURN	1.7E-06	2.0E-06	-	-
LCF	5.5E-08	-	-	-
BMT	1.2E-07	-	-	-
NOCF	6.1E-06	-	-	-

1. Results are a frequency-weighted sum of all release categories.

2. Results are integrated across the entire modeling domain.

3. Fraction of base case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded base case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.

Table 4-13 Conditional Mean (Across All Weather Trials) Population Exceeding Early-Phase Acute Red Bone Marrow Dose of 10 Rad-Eq (Persons): ME_2

Release Category	Frequency (/yr)	Base Case[2]	ME_2[2]	Fraction of Base Case[3]
ALL[1] (per yr)	**1.2E-05**	**3.3E-07**	**2.8E-07**	**0.830**
ISLOCA	1.3E-07	4.0E-03	3.8E-03	0.957
CIF	1.7E-06	1.2E-04	4.1E-05	0.334
COPEN-RCSINTACT	2.7E-07	8.2E-02	6.9E-02	0.837
COPEN-RCSVENT	1.3E-07	2.2E+00	1.8E+00	0.824
COPEN-HEADOFF	7.8E-08	1.9E-01	1.8E-01	0.946
ECF	5.1E-10	-	-	-
CF-Before-CD	2.1E-06	3.0E-03	2.3E-03	0.790
ICF-BURN	1.7E-06	-	-	-
LCF	5.5E-08	-	-	-
BMT	1.2E-07	-	-	-
NOCF	6.1E-06	-	-	-

1. Results are a frequency-weighted sum of all release categories.

2. Results are integrated across the entire modeling domain.

3. Fraction of base case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded base case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.

4.1.1.2 Accident Termination Time

The effect of terminating the accident release 36 hours after SAMG entry on the collective effective dose within 80 and 161 km (50 and 100 mi) is demonstrated in Table 4-14 and Table 4-15, respectively. For sensitivity analysis, only a subset of weather trials was sampled in order to increase computational efficiency. For this case, the reference case values are therefore the results from ME_2 described in the previous section. These values were selected for the reference case to minimize confounding effects from weather sampling with the effect of accident termination time.

The effect of terminating the release is a reduction on the collective total effective dose. On a frequency-weighted basis, the reduction is approximately 15 percent. Some release categories (such as ISLOCA or CIF release categories) are relatively unaffected, with a reduction on the order of a few percent, whereas other release categories (such as the intermediate containment failure (ICF) release category) are reduced by over 99 percent. The COPEN-RCSVENT and COPEN-RCSINTACT release categories are also noticeably affected, with reductions on the order of 10–20 percent.

The differential impact of the accident termination time on the relative contribution of release categories to the overall mean collective effective dose within 80 and 161 km (50 and 100 mi) is illustrated in Figure 4-11 and Figure 4-12, respectively. The frequency weighted reduction in the collective effective dose is a combination of the much lower conditional consequences for the ICF release category with a noticeable (greater than 10 percent) reduction in the conditional

consequences for COPEN-RCSVENT and COPEN-RCSINTACT release categories. The relative contribution of release categories to the mean collective effective dose is similar to the relative contribution of release categories to the cumulative cesium release shown in Figure 4-1, with CIF and CF-Before-CD release categories increasing slightly in relative importance and the ICF release category comprising a much smaller contributor.

The effect of terminating the accident release 36 hours after SAMG entry on the size of the population receiving elevated doses is demonstrated in Table 4-16 and Table 4-17. The effect of terminating the release 36 hours after SAMG entry has minimal impacts, suggesting the potential for elevated doses is largely attributable to that the portion of the release within 36 hours after SAMG entry.

Table 4-14 Conditional Mean (Across All Weather Trials) Collective Total Effective Dose (Person-Rem), 0–50 Miles: RE_4

Release Category	Frequency (/yr)	Reference Case (ME_2)	RE_4	Fraction of Reference Case[2]
ALL[1] (per yr)	**1.2E-05**	**3.5E+00**	**3.0E+00**	**0.862**
ISLOCA	1.3E-07	2.9E+05	2.6E+05	0.910
CIF	1.7E-06	5.5E+05	5.5E+05	0.986
COPEN-RCSINTACT	2.7E-07	1.1E+06	8.7E+05	0.810
COPEN-RCSVENT	1.3E-07	1.4E+06	1.3E+06	0.888
COPEN-HEADOFF	7.8E-08	1.4E+06	1.3E+06	0.970
ECF	5.1E-10	2.4E+05	4.9E+03	0.021
CF-Before-CD	2.1E-06	7.5E+05	7.4E+05	0.993
ICF-BURN	1.7E-06	2.2E+05	7.1E+02	0.003
LCF	5.5E-08	1.6E+03	7.4E+02	0.462
BMT	1.2E-07	1.0E+02	8.5E+01	0.846
NOCF	6.1E-06	6.0E+02	5.3E+02	0.881

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of reference case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded reference case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Table 4-15 Conditional Mean (Across All Weather Trials) Collective Total Effective Dose (Person-Rem), 0–100 Miles: RE_4

Release Category	Frequency (/yr)	Reference Case (ME_2)	RE_4	Fraction of Reference Case[2]
ALL[1] (per yr)	**1.2E-05**	**8.8E+00**	**7.7E+00**	**0.874**
ISLOCA	1.3E-07	5.9E+05	5.4E+05	0.919
CIF	1.7E-06	1.2E+06	1.1E+06	0.983
COPEN-RCSINTACT	2.7E-07	3.4E+06	2.6E+06	0.767
COPEN-RCSVENT	1.3E-07	4.6E+06	4.1E+06	0.877
COPEN-HEADOFF	7.8E-08	4.4E+06	4.3E+06	0.982
ECF	5.1E-10	4.6E+05	8.8E+03	0.019
CF-Before-CD	2.1E-06	2.0E+06	2.0E+06	0.995
ICF-BURN	1.7E-06	4.5E+05	9.9E+02	0.002
LCF	5.5E-08	2.3E+03	1.1E+03	0.457
BMT	1.2E-07	1.5E+02	1.2E+02	0.830
NOCF	6.1E-06	8.1E+02	7.2E+02	0.884

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of reference case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded reference case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Table 4-16 Conditional Mean (Across All Weather Trials) Population Exceeding Early-Phase Total Effective Dose Of 10 Rem (Persons): RE_4

Release Category	Frequency (/yr)	Reference Case (ME_2) [2]	RE_4[2]	Fraction of Reference Case[3]
ALL[1] (per yr)	1.2E-05	**6.3E-04**	6.3E-04	1.000
ISLOCA	1.3E-07	1.1E-01	1.1E-01	1.000
CIF	1.7E-06	3.6E-02	3.6E-02	1.000
COPEN-RCSINTACT	2.7E-07	1.3E+01	1.3E+01	1.000
COPEN-RCSVENT	1.3E-07	4.2E+03	4.2E+03	1.000
COPEN-HEADOFF	7.8E-08	1.1E+03	1.1E+03	1.000
ECF	5.1E-10	-	-	-
CF-Before-CD	2.1E-06	2.4E-01	2.4E-01	1.000
ICF-BURN	1.7E-06	-	-	-
LCF	5.5E-08	-	-	-
BMT	1.2E-07	-	-	-
NOCF	6.1E-06	-	-	-

1. Results are a frequency-weighted sum of all release categories.

2. Results are integrated across the entire modeling domain.

3. Fraction of reference case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded reference case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.

Table 4-17 Conditional Mean (Across All Weather Trials) Population Exceeding Early-Phase Acute Red Bone Marrow Dose Of 10 Rad-Eq (Persons): RE_4

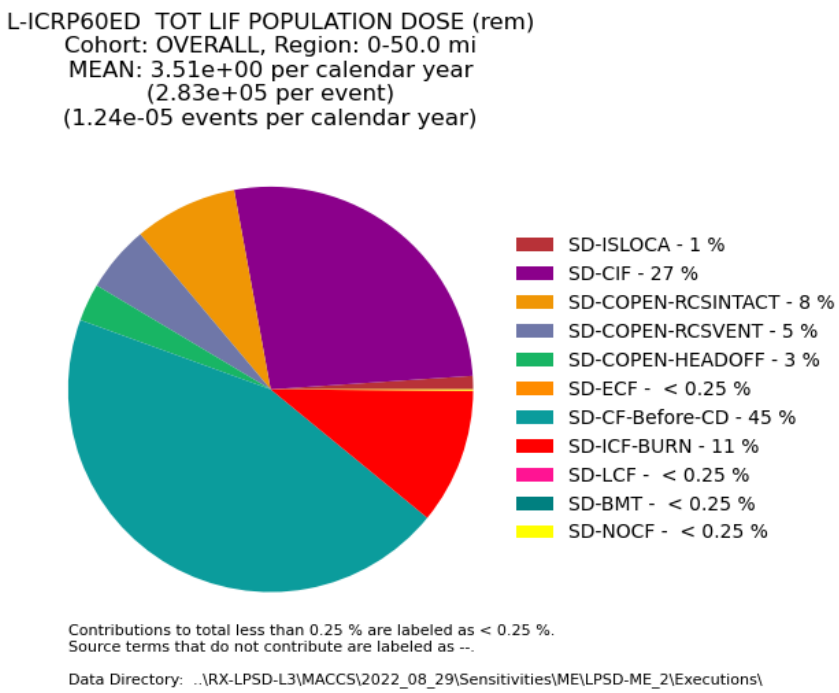
Release Category	Frequency (/yr)	Reference Case (ME_2) [2]	RE_4[2]	Fraction of Reference Case[3]
ALL[1] (per yr)	1.2E-05	**2.8E-07**	2.8E-07	1.000
ISLOCA	1.3E-07	3.8E-03	3.8E-03	1.000
CIF	1.7E-06	4.1E-05	4.1E-05	1.000
COPEN-RCSINTACT	2.7E-07	6.9E-02	6.9E-02	1.000
COPEN-RCSVENT	1.3E-07	1.8E+00	1.8E+00	1.000
COPEN-HEADOFF	7.8E-08	1.8E-01	1.8E-01	1.000
ECF	5.1E-10	-	-	-
CF-Before-CD	2.1E-06	2.3E-03	2.3E-03	1.000
ICF-BURN	1.7E-06	-	-	-
LCF	5.5E-08	-	-	-
BMT	1.2E-07	-	-	-
NOCF	6.1E-06	-	-	-

1. Results are a frequency-weighted sum of all release categories.

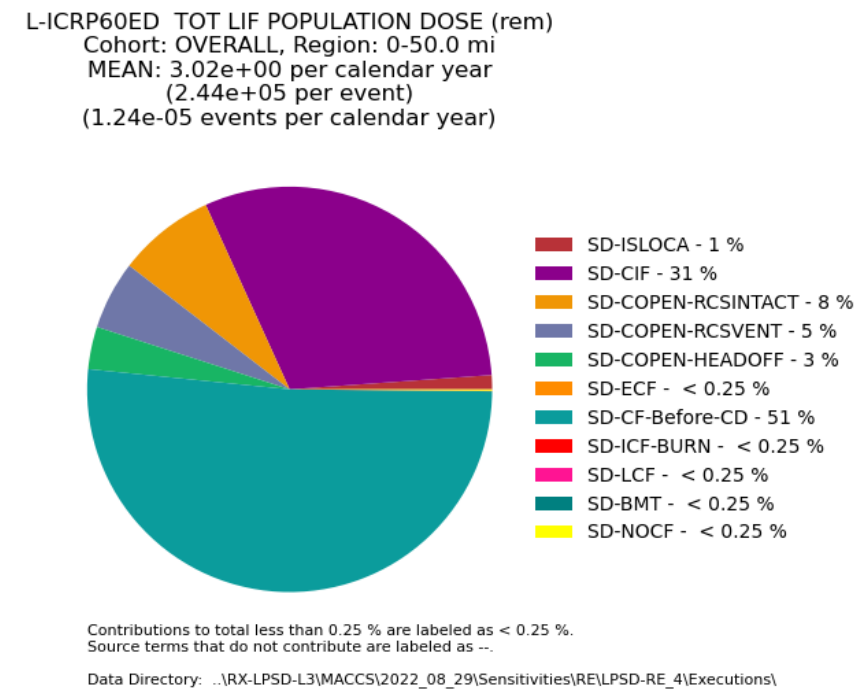
2. Results are integrated across the entire modeling domain.

3. Fraction of reference case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded reference case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.

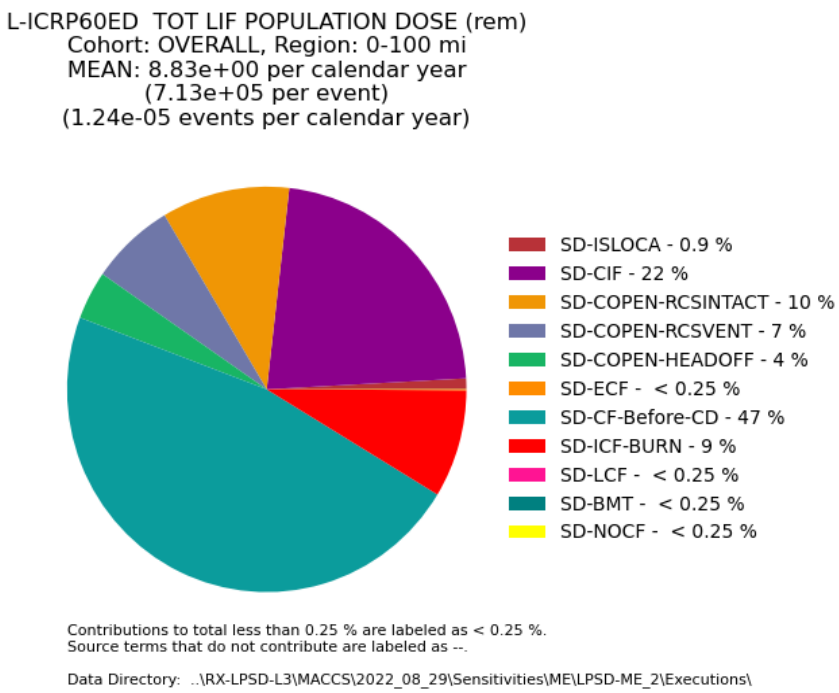


Reference Case (ME_2)

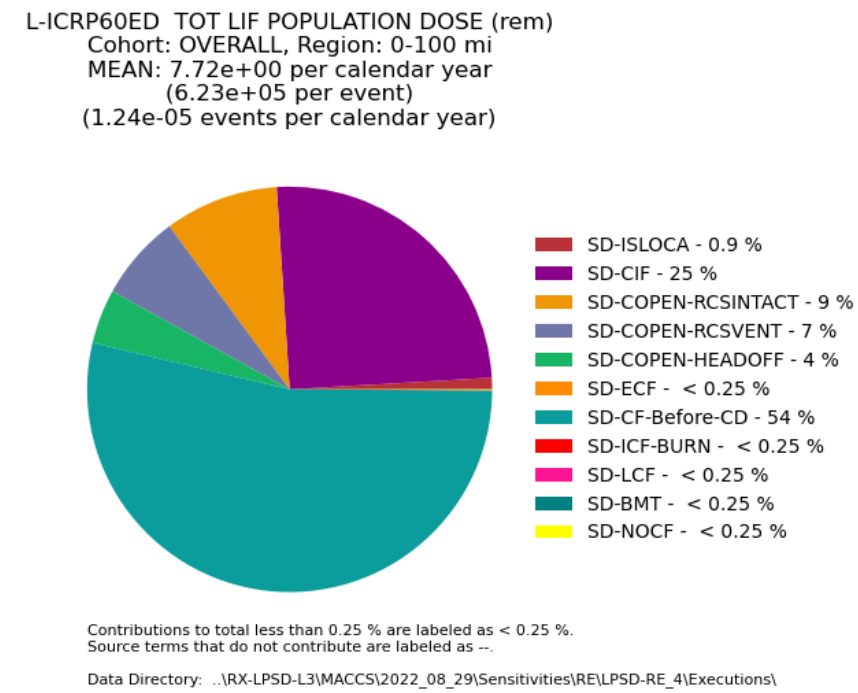


RE_4

Figure 4-11 Relative Contribution of Release Categories to Overall Mean Collective Total Effective Dose, 0–50 Miles: RE_4



Reference Case (ME_2)



RE_4

Figure 4-12 Relative Contribution of Release Categories to Overall Mean Collective Effective Dose, 0–100 Miles: RE_4

4.1.1.3 Low-Dose Cancer Risk Estimation

Inspection of the results for estimated collective effective dose, or size of populations receiving elevated doses, arising from the use of a model that estimates cancer risk based only on annual individual doses greater than 0.05 Sv (5 rem), or lifetime individual doses greater than 0.1 Sv (10 rem) shows that (as expected) there is no difference between the results of the reference case and the results for sensitivity case HE-2. For this sensitivity analysis, only a subset of weather trials was sampled in order to increase computational efficiency. For this case, the reference case values are therefore the results from ME_2 described previously. These values were selected for the reference case to minimize confounding effects from weather sampling with the effect of using a dose truncation model. The ratio of the results of the reference and sensitivity case were 1.000 for all release categories and are therefore not reproduced here.

4.2 Early Health Effects

The following discussion is adapted from Section 4.2 of NRC (2022a) and is modified to discuss the effect of the different release category characteristics associated with the LPSD analysis documented in NRC (2025). As in Section 4.1, results are provided on a conditional (i.e., not frequency-weighted) basis for all release categories.

Early health effects selected for risk integration in the project include early fatalities from either hematopoietic syndrome, pulmonary syndrome, or gastrointestinal syndrome. Early fatalities are characterized both with the MACCS Type 8 output, to provide the population-weighted (i.e., individual) risk of an early fatality within 1 mile of the site boundary,[9] and with the MACCS Type 1 output, to provide the total early fatality cases within 50 miles of the site. The population-weighted early fatality risk is simply the total number of early fatality cases within a given region divided by the population within that region. An alternate approach to characterizing the individual risk, which does not credit the sparseness of the population around the site, is the average individual risk obtained using the MACCS Type 4 output. This result is generated by MACCS by averaging all risk values at a given distance assuming that there is an individual in every radial sector at that distance. Because early fatalities are characterized by a threshold dose, the results may indicate zero early fatalities if doses are high but slightly below the threshold for early fatalities. However, the threshold dose for prodromal vomiting is slightly lower than the threshold doses for early fatalities (0.5 Gy-eq to the stomach versus 2.32 Gy-eq to the red bone marrow) and, therefore, results for prodromal vomiting were examined to understand how close a given cohort might be to the potential for early fatalities. In addition, the range at which early fatalities were projected to be possible was also examined.

Table 4-18 shows the projected mean number of early fatalities within 50 miles. These results represent a mean value over all weather trials, and a fractional apportionment of the population of each grid element to each cohort. Because of these two factors, the mean value of the total health effect cases may be less than a single person. Such results suggest that only a limited number of trials, coupled with a very small population at risk, resulted in projected early fatalities. In Table 4-18, the results are given by types of cohorts as well as overall, to evaluate which populations are at risk. It may be seen that the total number of early fatality cases is very

[9] The early fatality safety goal is generally interpreted to be the population-weighted risk of an early fatality within 1 mile of the site boundary. With the assumption in the model that the EAB is located at 0.75 miles, the safety goal risk would be defined as the risk within 1.75 miles.

low (much less than one person on average). They only arise in the non-evacuating cohort from the COPEN-RCSVENT and COPEN-HEADOFF release categories. These very low values reflect essentially zero early fatalities.

Table 4-18 Conditional Mean (Across All Weather Trials) Number of Early Fatality Cases Within 50 Miles, by Release Category and Cohort Type

Release Category	EVAC	NON-EVAC	SCH	SHADOW	IND	OVERALL
ISLOCA	-	-	-	-	-	-
CIF	-	-	-	-	-	-
COPEN-RCSINTACT	-	-	-	-	-	-
COPEN-RCSVENT	-	2.7E-04	-	-	-	2.7E-04
COPEN-HEADOFF	-	3.6E-07	-	-	-	3.6E-07
ECF	-	-	-	-	-	-
CF-Before-CD	-	-	-	-	-	-
ICF-BURN	-	-	-	-	-	-
LCF	-	-	-	-	-	-
BMT	-	-	-	-	-	-
NOCF	-	-	-	-	-	-

Notes:

1. *Conditional mean values for health effects cases of less than one arise from fractional populations coupled with infrequent occurrence of adverse weather.*
2. *EVAC refers to the sum of all 12 evacuating cohorts (4 cohorts each for 0–10, 10–15, and 15–20 miles); NON-EVAC refers to the non-evacuating cohort, which includes those who do not evacuate when ordered to do so, as well as those outside of the evacuation zone; SCH refers to the schools cohort, if modeled; SHADOW refers to the 20 percent of the population immediately outside of the evacuation zone that voluntarily evacuates; IND refers to the restricted access industrial facility employees; and OVERALL refers to the combined set of all cohorts.*
3. *Dashes represent MACCS results that are identically zero.*

As discussed in NRC (2022a), the total number of projected prodromal vomiting cases was examined to explore the margin to a potential cliff-edge effect. Prodromal vomiting cases, shown in Table 4-19, show a similar pattern to Table 4-18. Although the number of prodromal vomiting cases are significantly higher than the number of early fatalities, they are still very low (with less than a single case on average). This suggests that only a very small (essentially zero) population would be expected to receive the high acute doses needed to yield early fatalities.

Table 4-19 Conditional Mean (Across All Weather Trials) Number of Early Injury (Prodromal Vomiting) Cases within 50 Miles, by Release Category and Cohort Type

Release Category	EVAC	NON-EVAC	SCH	SHADOW	IND
ISLOCA	-	1.4E-07	-	-	-
CIF	-	-	-	-	-
COPEN-RCSINTACT	-	2.2E-05	-	-	-
COPEN-RCSVENT	1.9E-04	6.4E-03	-	-	-
COPEN-HEADOFF	-	2.6E-04	-	-	-
ECF	-	-	-	-	-
CF-Before-CD	-	-	-	-	-
ICF-BURN	-	-	-	-	-
LCF	-	-	-	-	-
BMT	-	-	-	-	-
NOCF	-	-	-	-	-

Notes:

1. *Conditional mean values for health effects cases of less than one arise from fractional populations coupled with infrequent occurrence of adverse weather.*
2. *EVAC refers to the sum of all 12 evacuating cohorts (4 cohorts each for 0–10, 10–15, and 15–20 miles); NON-EVAC refers to the non-evacuating cohort, which includes those who do not evacuate when ordered to do so, as well as those outside of the evacuation zone; SCH refers to the schools cohort, if modeled; SHADOW refers to the 20 percent of the population immediately outside of the evacuation zone that voluntarily evacuates; IND refers to the restricted access industrial facility employees; and OVERALL refers to the combined set of all cohorts.*
3. *Dashes represent MACCS results that are identically zero.*

As seen in Table 4-18, early fatality cases were only observed (if at all) in the non-evacuating cohort. Unlike the results for the at-power release categories, there were no early health effects arising within the evacuating cohorts. As discussed earlier, the risk to an individual may be represented either by estimating the population-weighted risk or an average individual risk. Comparison of these two results, one of which accounts for the distribution of population around the site (the MACCS Type 8 population-weighted risk) and one of which does not (the MACCS Type 4 average individual risk), provides insights on how the distribution of population can affect the computed early fatality risk. As seen in Table 4-20, comparison of the population-weighted individual risk to the average individual risk shows that the low individual risk may be related to the sparse population within 1 mile of the site boundary. It may be noted that there is an extremely small projected early fatality risk associated with release category COPEN-RCSINTACT when computed using the Type 4 average individual EF risk. Taken together, these results suggest (consistent with the observations based on the at-power release categories) that because only a few of the 64 radial sectors have any population within this distance, the likelihood that the wind is blowing into a populated sector during a large release is extremely low.

Table 4-20 Conditional Mean (Across All Weather Trials) Value of Individual Early Fatality Risk, by Release Category and Cohort Type

Release Category	Population-Weighted EF Risk, 0–1.8 miles			Average Individual EF Risk, 0.7–1 miles	
	1GPT	NON-EVAC	OVERALL	1GPT	NON-EVAC
ISLOCA	-	-	-	-	-
CIF	-	-	-	-	-
COPEN-RCSINTACT	-	-	-	-	3.9E-07
COPEN-RCSVENT	-	2.1E-03	1.1E-05	6.4E-09	2.0E-02
COPEN-HEADOFF	-	2.9E-06	1.4E-08	-	1.3E-04
ECF	-	-	-	-	-
CF-Before-CD	-	-	-	-	-
ICF-BURN	-	-	-	-	-
LCF	-	-	-	-	-
BMT	-	-	-	-	-
NOCF	-	-	-	-	-

Note: Dashes represent MACCS results that are identically zero.

As in NRC (2022a), the range at which early fatalities may occur was examined. This examination made use of the MACCS Type 2 output, which is provided for each early-phase cohort and considers the effect of protective actions such as sheltering and evacuation. This distance is shown in Table 4-21 for all release categories. Both the mean and the 95th percentile are provided. The results are consistent with the results discussed previously, that is, the distances at which early fatalities are possible are either within the 0.75-mile site boundary or only slightly beyond, where there is very limited population. The release category with the longest early fatality range (COPEN-RCSVENT) was the release category with the highest early fatality risk. For the slowest evacuating tail cohort, the ranges (shown in Table 4-21) at which early fatalities are possible are well within the site boundary.

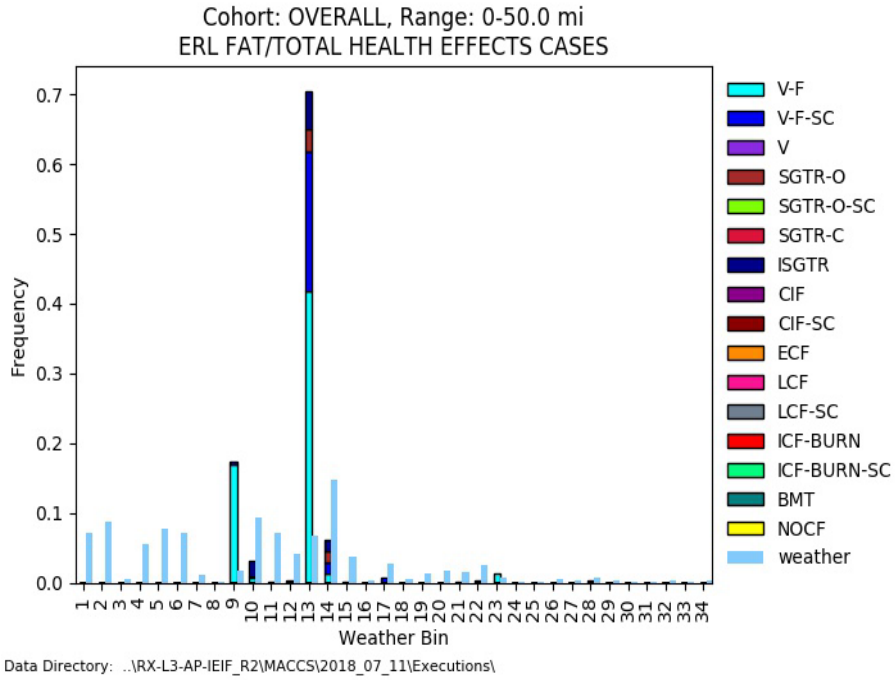
Table 4-21 Range in Miles at Which Early Fatality Risk >0 for Non-Evacuating and 10-Mile Tail Cohorts, Conditional Mean and 95th Percentile Across All Weather Trials

Release Category	NE, Conditional Mean	NE, 95th Percentile	1GPT, Conditional Mean	1GPT, 95th Percentile
ISLOCA	0.18	0.26	-	-
CIF	0.037	****	-	-
COPEN-RCSINTACT	0.41	0.78	0.038	****
COPEN-RCSVENT	1.6	2.4	0.35	0.73
COPEN-HEADOFF	0.68	0.94	-	-
ECF	-	-	-	-
CF-Before-CD	0.15	****	-	-
ICF-BURN	-	-	-	-
LCF	-	-	-	-
BMT	-	-	-	-
NOCF	-	-	-	-

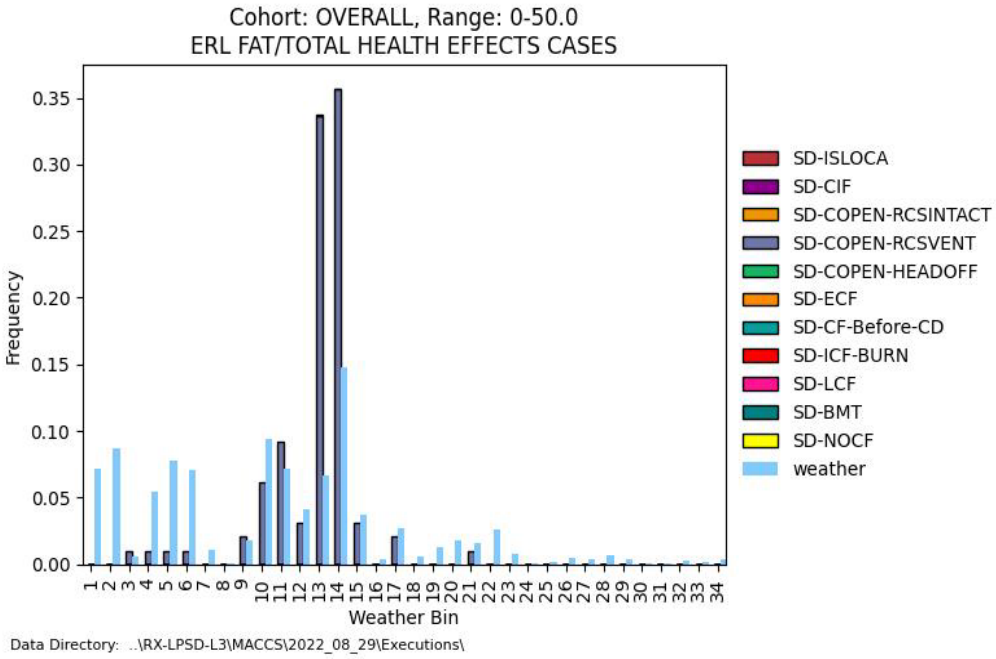
***** indicates that the mean value is greater than the 95th percentile*

Note: Dashes represent MACCS results that are identically zero.

As demonstrated in NRC (2022a), the weather conditions leading to early fatalities were examined by use of the MACCS RISCAT output. This output shows the relative contribution of each weather bin to the mean value of any MACCS result of interest. A graphical representation of this output is shown in Figure 4-13 (for the contribution of weather bins and release categories to the total number of early fatality cases) and Figure 4-14 (for the contribution of weather bins and release categories to the risk to an individual within 1 mile of the site boundary of early fatality). The results from the reactor, at-power, internal events and internal floods analysis are shown for comparison. Consistent with the reactor at-power analysis, examination of Figure 4-13 and Figure 4-14 suggests that early fatalities arise primarily under low wind speed, stable conditions, that is, predominantly under Bin 13, which represents weather sequences starting with F stability and wind speeds less than 1 m/s (see Table 3.2-10 of NRC 2022a). This is reasonable given that these conditions give rise to relatively high centerline air and ground concentrations. It may be noted that the analyses in the Level 3 PRA project do not use the Regulatory Guide 1.145 meander model, which accounts for enhanced dispersion under stable, light wind conditions. This model was not used because the dispersion coefficients used in the Level 3 PRA project were incompatible with the meander factors provided in Regulatory Guide 1.145. Use of a more realistic treatment of diffusion under stable, low-wind speed conditions may reduce these already low risks even further. It may also be noted that the relative likelihood of these conditions may have a dependence upon the time of day or the season of the year, which could also affect the evacuation behavior. They could also have a dependence upon the relative frequency with which the wind blows towards close-in populated sectors. However, these potential dependencies were not explored in this analysis. Because these early fatality results appear to arise from only a few weather bins, the effect of alternate weather years in which these bins were relatively more or less frequent than the selected year may be more pronounced for estimation of early fatality risk.

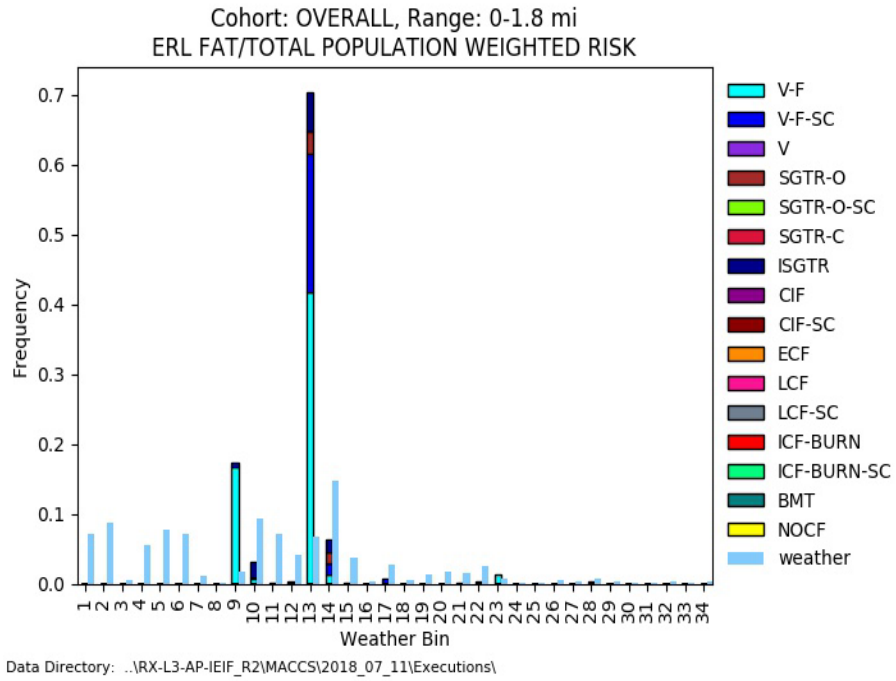


Reactor, at-power, internal events and floods (from NRC 2022a)

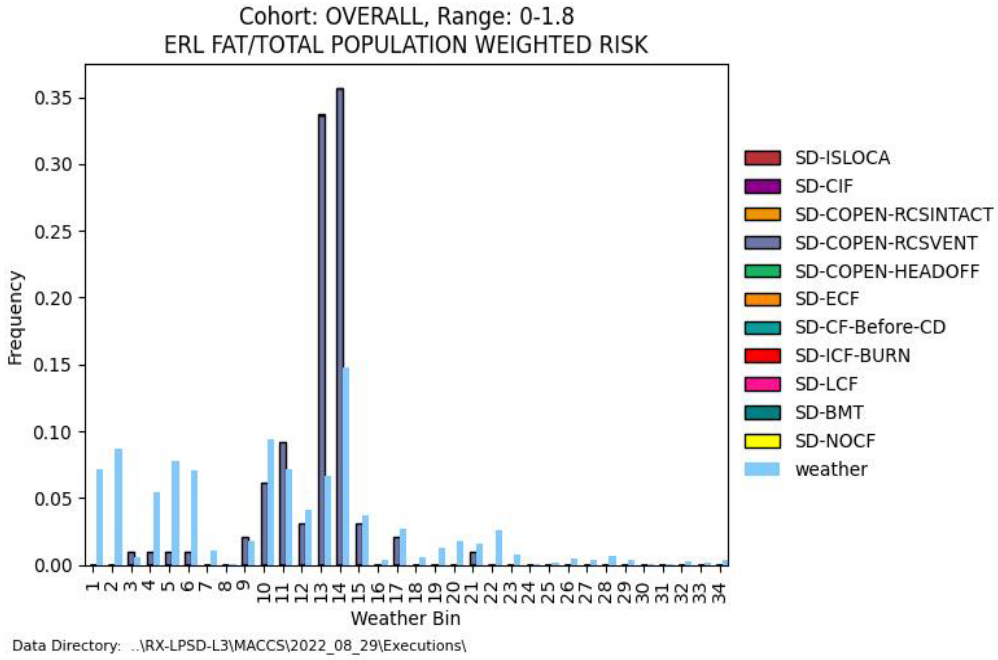


Low-power and shutdown events

Figure 4-13 Relative Contribution of Weather Bins and Release Categories to Mean (Across All Weather Trials) Total Early Fatality Cases



Reactor, at-power, internal events and floods (from NRC 2022a)



Low-power and shutdown events

Figure 4-14 Relative Contribution of Weather Bins and Release Categories to Conditional Mean (Across All Weather Trials) Population-Weighted Individual Early Fatality Risk

The CCDFs of the total number of early fatality cases, and of the risk to an individual within 1 mile of the site boundary of early fatality, are shown in Figure 4-15 and Figure 4-16, respectively. Because the early fatality risks predominantly arise only from the COPEN-RCSVENT release category, the curves for the COPEN-RCSVENT overlaps the curve for the TOTAL. At a frequency of 10^{-10} per calendar-year, no weather conditions resulted in even one early fatality per event, and the risk to individuals within 1 mile of the site boundary is no higher than 10^{-2} per event.

In summary, as in the reactor at-power analysis documented in NRC (2022a), the projected number of early fatalities is very low. This result, and the associated insights, do not change because of a consideration of events initiated during LPSD operations and the summary from that document is repeated here. In this analysis, early fatality risks are effectively zero. Figure 4-16 shows that the frequency of having even a single early fatality is less than 10^{-10} per calendar-year. To the extent that early fatalities are possible at this site, they would most likely arise within a non-evacuating population located very close to the site under adverse (stable, low wind speed) meteorological conditions. The risks are also low because of the sparse population within the region over which early fatalities are possible, which makes the likelihood that the wind is blowing into a populated sector with meteorological conditions that could lead to early fatalities extremely low. Early fatalities in this analysis appear to arise only under the unlikely combination of all the following conditions:

- Occurrence of a relatively large and fast release
- Occurrence of adverse meteorological conditions (primarily, stable, low wind speed conditions; see, e.g., Figure 4-13 and Figure 4-14)
- Wind blowing in the direction of a populated sector very close to the site (see, e.g., Table 4-19)
- Delayed or slow evacuation of the populations toward which the winds are blowing (see, e.g., Table 4-18, Table 4-20, and Table 4-21)

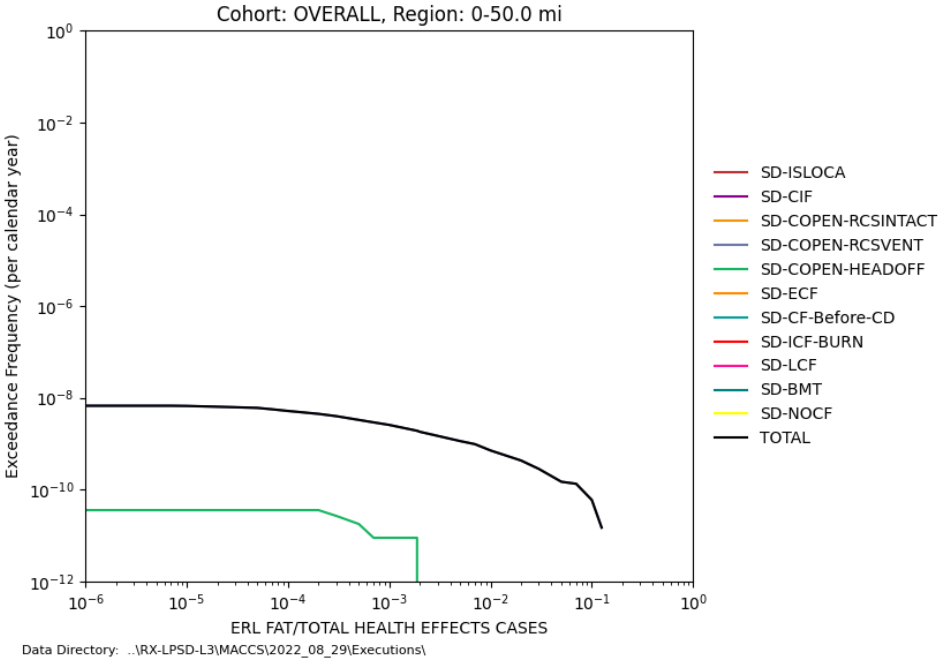


Figure 4-15 Complementary Cumulative Distribution Function of Total Early Fatality Cases within 50 Miles

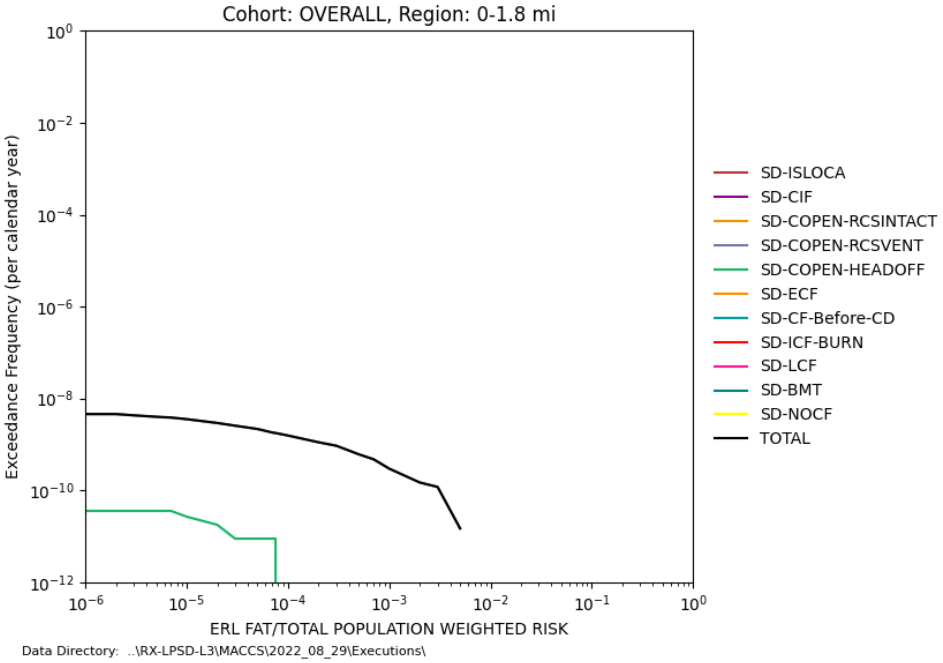


Figure 4-16 Complementary Cumulative Distribution Function of Population-Weighted Individual Early Fatality Risk within 1 Mile of Site Boundary

4.2.1 Sensitivity Cases

4.2.1.1 Meteorological Sampling

The effect of sampling only a subset of the meteorological data on the risk of early health effects is shown in Table 4-22, Table 4-23, and Table 4-24. The sensitivity of these metrics, which represent the small subset of the population that may receive high doses, is like that of the population receiving elevated doses seen in Table 4-8, Table 4-9, and Table 4-10. The overall frequency-weighted results can vary by a factor of approximately 2. The effect on release categories with very low base case values can be very significant, with some release categories exhibiting a very low base case value and an identically zero result for ME_2. This increased sensitivity is consistent with the observation that high doses arise from adverse but infrequent weather conditions, and sampling less than the complete set of all weather trials may miss some of these adverse weather conditions.

Table 4-22 Individual Early Fatality Risk, 0–1.8 Miles (Mean Value Across All Weather Trials): ME_2

Release Category	Frequency (/yr)	Base Case	ME_2	Fraction of Base Case[2]
ALL[1] (per yr)	**1.2E-05**	**1.4E-12**	**8.9E-13**	**0.653**
ISLOCA	1.3E-07	-	-	-
CIF	1.7E-06	-	-	-
COPEN-RCSINTACT	2.7E-07	-	-	-
COPEN-RCSVENT	1.3E-07	1.1E-05	6.9E-06	0.653
COPEN-HEADOFF	7.8E-08	1.4E-08	-	0.000
ECF	5.1E-10	-	-	-
CF-Before-CD	2.1E-06	-	-	-
ICF-BURN	1.7E-06	-	-	-
LCF	5.5E-08	-	-	-
BMT	1.2E-07	-	-	-
NOCF	6.1E-06	-	-	-

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of base case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded base case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.

Table 4-23 Early Fatality Cases, 0–50 Miles (Persons) (Conditional Mean Value Across All Weather Trials): ME_2

Release Category	Frequency (/yr)	Base Case	ME_2	Fraction of Base Case[2]
ALL[1] (per yr)	**1.2E-05**	**3.5E-11**	**2.3E-11**	**0.664**
ISLOCA	1.3E-07	-	-	-
CIF	1.7E-06	-	-	-
COPEN-RCSINTACT	2.7E-07	-	-	-
COPEN-RCSVENT	1.3E-07	2.7E-04	1.8E-04	0.664
COPEN-HEADOFF	7.8E-08	3.6E-07	-	0.000
ECF	5.1E-10	-	-	-
CF-Before-CD	2.1E-06	-	-	-
ICF-BURN	1.7E-06	-	-	-
LCF	5.5E-08	-	-	-
BMT	1.2E-07	-	-	-
NOCF	6.1E-06	-	-	-

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of base case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded base case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.

Table 4-24 Early Injury (Prodromal Vomiting) Cases, 0–50 Miles (Persons) (Conditional Mean Value Across All Weather Trials): ME_2

Release Category	Frequency (/yr)	Base Case	ME_2	Fraction of Base Case[2]
ALL[1] (per yr)	**1.2E-05**	**8.8E-10**	**9.1E-10**	**1.037**
ISLOCA	1.3E-07	1.4E-07	-	0.000
CIF	1.7E-06	-	-	-
COPEN-RCSINTACT	2.7E-07	2.2E-05	1.9E-05	0.885
COPEN-RCSVENT	1.3E-07	6.6E-03	6.9E-03	1.044
COPEN-HEADOFF	7.8E-08	2.6E-04	2.0E-04	0.793
ECF	5.1E-10	-	-	-
CF-Before-CD	2.1E-06	-	-	-
ICF-BURN	1.7E-06	-	-	-
LCF	5.5E-08	-	-	-
BMT	1.2E-07	-	-	-
NOCF	6.1E-06	-	-	-

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of base case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded base case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.

4.2.1.2 Accident Termination Time

The effect of terminating the accident release 36 hours after SAMG entry on the risk of early health effects is shown in Table 4-25, Table 4-26, and Table 4-27. For sensitivity analysis, only a subset of weather trials was sampled to increase computational efficiency. For this case, the reference case values are therefore the results from ME_2 described in the previous section. These values were selected for the reference case to minimize confounding effects from weather sampling with the effect of accident termination time. The effect of terminating the release 36 hours after SAMG entry has minimal impacts on the risk of early health effects, suggesting the potential for elevated doses is largely attributable to that portion of the release that occurs within 36 hours after SAMG entry. This is like the effect of accident termination on the size of the population receiving elevated doses, as demonstrated in Table 4-13 and Table 4-14.

Table 4-25 Individual Early Fatality Risk, 0–1.8 Miles (Conditional Mean Value Across All Weather Trials): RE_4

Release Category	Frequency (/yr)	Reference Case (ME_2)	RE_4	Fraction of Reference Case[2]
ALL[1] (per yr)	**1.2E-05**	**8.9E-13**	**8.9E-13**	**1.000**
ISLOCA	1.3E-07	-	-	-
CIF	1.7E-06	-	-	-
COPEN-RCSINTACT	2.7E-07	-	-	-
COPEN-RCSVENT	1.3E-07	6.9E-06	6.9E-06	1.000
COPEN-HEADOFF	7.8E-08	-	-	-
ECF	5.1E-10	-	-	-
CF-Before-CD	2.1E-06	-	-	-
ICF-BURN	1.7E-06	-	-	-
LCF	5.5E-08	-	-	-
BMT	1.2E-07	-	-	-
NOCF	6.1E-06	-	-	-

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of reference case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded reference case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.

Table 4-26 Early Fatality Cases, 0–50 Miles, Persons (Conditional Mean Value Across All Weather Trials): RE_4

Release Category	Frequency (/yr)	Reference Case (ME_2)	RE_4	Fraction of Reference Case[2]
ALL[1] (per yr)	**1.2E-05**	**2.3E-11**	**2.3E-11**	**1.000**
ISLOCA	1.3E-07	-	-	-
CIF	1.7E-06	-	-	-
COPEN-RCSINTACT	2.7E-07	-	-	-
COPEN-RCSVENT	1.3E-07	1.8E-04	1.8E-04	1.000
COPEN-HEADOFF	7.8E-08	-	-	-
ECF	5.1E-10	-	-	-
CF-Before-CD	2.1E-06	-	-	-
ICF-BURN	1.7E-06	-	-	-
LCF	5.5E-08	-	-	-
BMT	1.2E-07	-	-	-
NOCF	6.1E-06	-	-	-

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of reference case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded reference case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.

Table 4-27 Early Injury (Prodromal Vomiting) Cases, 0–50 Miles, Persons (Conditional Mean Value Across All Weather Trials): RE_4

Release Category	Frequency (/yr)	Reference Case (ME_2)	RE_4	Fraction of Reference Case[2]
ALL[1] (per yr)	**1.2E-05**	**9.1E-10**	**9.1E-10**	**1.000**
ISLOCA	1.3E-07	-	-	-
CIF	1.7E-06	-	-	-
COPEN-RCSINTACT	2.7E-07	1.9E-05	1.9E-05	1.000
COPEN-RCSVENT	1.3E-07	6.9E-03	6.9E-03	1.000
COPEN-HEADOFF	7.8E-08	2.0E-04	2.0E-04	1.000
ECF	5.1E-10	-	-	-
CF-Before-CD	2.1E-06	-	-	-
ICF-BURN	1.7E-06	-	-	-
LCF	5.5E-08	-	-	-
BMT	1.2E-07	-	-	-
NOCF	6.1E-06	-	-	-

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of reference case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded reference case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.

4.2.1.3 Low-Dose Cancer Risk Estimation

Inspection of the results for estimated early health effects arising from the use of a model that estimates cancer risk based only on annual individual doses greater than 0.05 Sv (5 rem), or lifetime individual doses greater than 0.1 Sv (10 rem) shows that (as expected) there is no difference between the results of the reference case and the results for sensitivity case HE-2. For this sensitivity analysis, only a subset of weather trials was sampled to increase computational efficiency. For this case, the reference case values are therefore the results from ME_2 described previously. These values were selected for the reference case to minimize confounding effects from weather sampling with the effect of using a dose truncation model. The ratio of the results of the reference and sensitivity case were 1.000 for all release categories and are therefore not reproduced here.

4.3 Latent Health Effects

The following discussion is adapted from Section 4.3 of NRC (2022a) and is modified to discuss the effect of the different release category characteristics associated with the LPSD analysis documented in NRC (2025). As in Section 4.1, results are provided on a conditional (i.e., not frequency-weighted) basis for all release categories. Latent health effects are examined using the MACCS Type 1 output (total health effects cases) and Type 8 output (population-weighted individual fatality risk). The latent fatalities are characterized both in terms of total latent fatality cases within 50 and 100 miles from the point of release and the population-weighted risk of a latent fatality averaged over the region within 10 miles of the point of release.

4.3.1 Total Latent Fatalities (MACCS Type 1)

A breakdown of the number of latent fatality cases by release category and cohort type is shown in Table 4-28 (within 50 miles) and Table 4-29 (within 100 miles). The results are broken down by types of cohorts to evaluate which populations are at risk. It may be noted that the evacuating, schools, shadow, and restricted access industrial facility cohorts are all located within 50 miles, and therefore there is no change in the results for these cohorts between 50 and 100 miles. For the non-evacuating and CHRONC cohorts, the difference between the results within 50 miles and within 100 miles represents the additional cases projected beyond 50 miles.

Examination of the conditional mean number of latent fatalities within 50 and 100 miles by release category and accident phase (including inspection of the MACCS intermediate results), suggests that the observations drawn from the at-power scenarios also apply to the LPSD events, namely:

- Most cases (typically 80-90 percent, with the exception of the COPEN-RCSVENT release category) arise in the late phase and therefore result from exposures to populations that are either never subject to long-term protective actions, or who reoccupy properties after decontamination and/or natural weathering have reduced doses to below the habitability criteria. As seen earlier in Figure 4-3 and Figure 4-5, this is associated with conditional mean chronic lifetime doses on the order of 1–10 rem or lower.

- Most of the early-phase contributions to the total are associated with the populations beyond the 20-mile evacuation zone. Outside the evacuation zone, the population is assigned to the non-evacuating cohort. As seen earlier in Figure 4-2 and Figure 4-4, this cohort is characterized by conditional mean lifetime doses on the order of 1–10 rem or lower.

- The relative increase in projected total latent fatality cases arising from exposures beyond 50 miles is, on average, about a factor of 2. However, the magnitude of the relative increase is dependent upon the magnitude of the release.

The dependence of the total latent fatalities on the cesium release magnitude is shown in Figure 4-17. Both LPSD and reactor, at-power, internal events and internal floods (IEIF) release categories are shown for comparison. As expected, the results from both sets of scenarios show consistent trends. A pronounced sublinearity in LCF cases as a function of cesium release magnitude is visible in Figure 4-17, with relatively fewer LCF cases per MCi released for large releases. As illustrated in Figure 4-18, the increase in projected total latent fatality cases arising from exposures beyond 50 miles is dependent upon the magnitude of the release. As seen in Figure 4-3, showing the peak total effective dose (rem) from late-phase exposure, the lower magnitude releases result in exposures being concentrated closer to the site, whereas larger magnitude releases may give rise to elevated exposures at longer distances, suggesting that the collective effects will converge more slowly for those cases.

Table 4-28 Conditional Mean (Across All Weather Trials) Number of Latent Fatality Cases within 50 Miles by Cohort Type

Release Category	EVAC	NON-EVAC	SCH	SHADOW	IND	CHRONC	OVERALL
ISLOCA	<1	15	<1	<1	<1	140	150
CIF	<1	12	<1	<1	<1	280	300
COPEN-RCSINTACT	1.3	100	<1	<1	<1	430	540
COPEN-RCSVENT	15	250	<1	<1	<1	450	710
COPEN-HEADOFF	8.7	130	<1	<1	<1	530	670
ECF	<1	11	<1	<1	<1	110	120
CF-Before-CD	<1	28	<1	<1	<1	370	400
ICF-BURN	<1	17	<1	<1	<1	98	120
LCF	<1	<1	<1	<1	<1	<1	<1
BMT	<1	<1	<1	<1	<1	<1	<1
NOCF	<1	<1	<1	<1	<1	<1	<1

Note: EVAC refers to the sum of all 12 evacuating cohorts (4 cohorts each for 0–10, 10–15, and 15–20 miles); NON-EVAC refers to the non-evacuating cohort, which includes those who do not evacuate when ordered to do so, as well as those outside of the evacuation zone; SCH refers to the schools cohort, if modeled; SHADOW refers to the 20 percent of the population immediately outside of the evacuation zone that voluntarily evacuates; IND refers to the restricted access industrial facility employees; CHRONC refers to the number of cases arising from exposures after the early phase has ended; and OVERALL refers to the combined set of all cohorts.

Table 4-29 Conditional Mean (Across All Weather Trials) Number of Latent Fatality Cases within 100 Miles by Cohort Type

Release Category	EVAC	NON-EVAC	SCH	SHADOW	IND	CHRONC	OVERALL
ISLOCA	<1	28	<1	<1	<1	270	300
CIF	<1	23	<1	<1	<1	590	610
COPEN-RCSINTACT	1.3	320	<1	<1	<1	1400	1700
COPEN-RCSVENT	15	590	<1	<1	<1	1800	2400
COPEN-HEADOFF	8.7	310	<1	<1	<1	1900	2300
ECF	<1	21	<1	<1	<1	220	240
CF-Before-CD	<1	54	<1	<1	<1	1000	1100
ICF-BURN	<1	33	<1	<1	<1	200	230
LCF	<1	<1	<1	<1	<1	<1	1
BMT	<1	<1	<1	<1	<1	<1	<1
NOCF	<1	<1	<1	<1	<1	<1	<1

Note: EVAC refers to the sum of all 12 evacuating cohorts (4 cohorts each for 0–10, 10–15, and 15–20 miles); NON-EVAC refers to the non-evacuating cohort, which includes those who do not evacuate when ordered to do so, as well as those outside of the evacuation zone; SCH refers to the schools cohort, if modeled; SHADOW refers to the 20 percent of the population immediately outside of the evacuation zone that voluntarily evacuates; IND refers to the restricted access industrial facility employees; CHRONC refers to the number of cases arising from exposures after the early phase has ended; and OVERALL refers to the combined set of all cohorts.

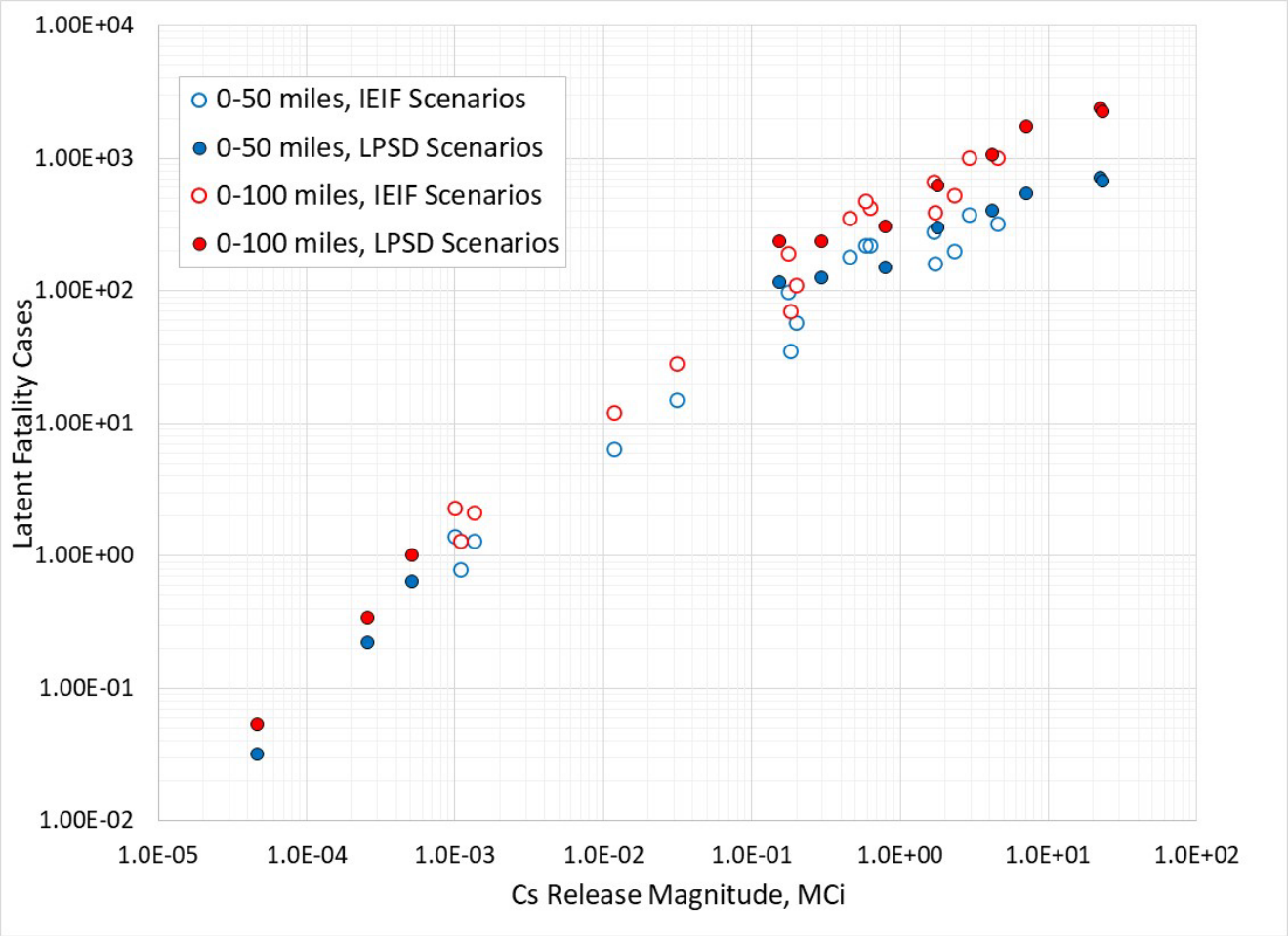


Figure 4-17 Total Latent Fatalities as a Function of Cesium Release Magnitude, LPSD and IEIF Release Categories

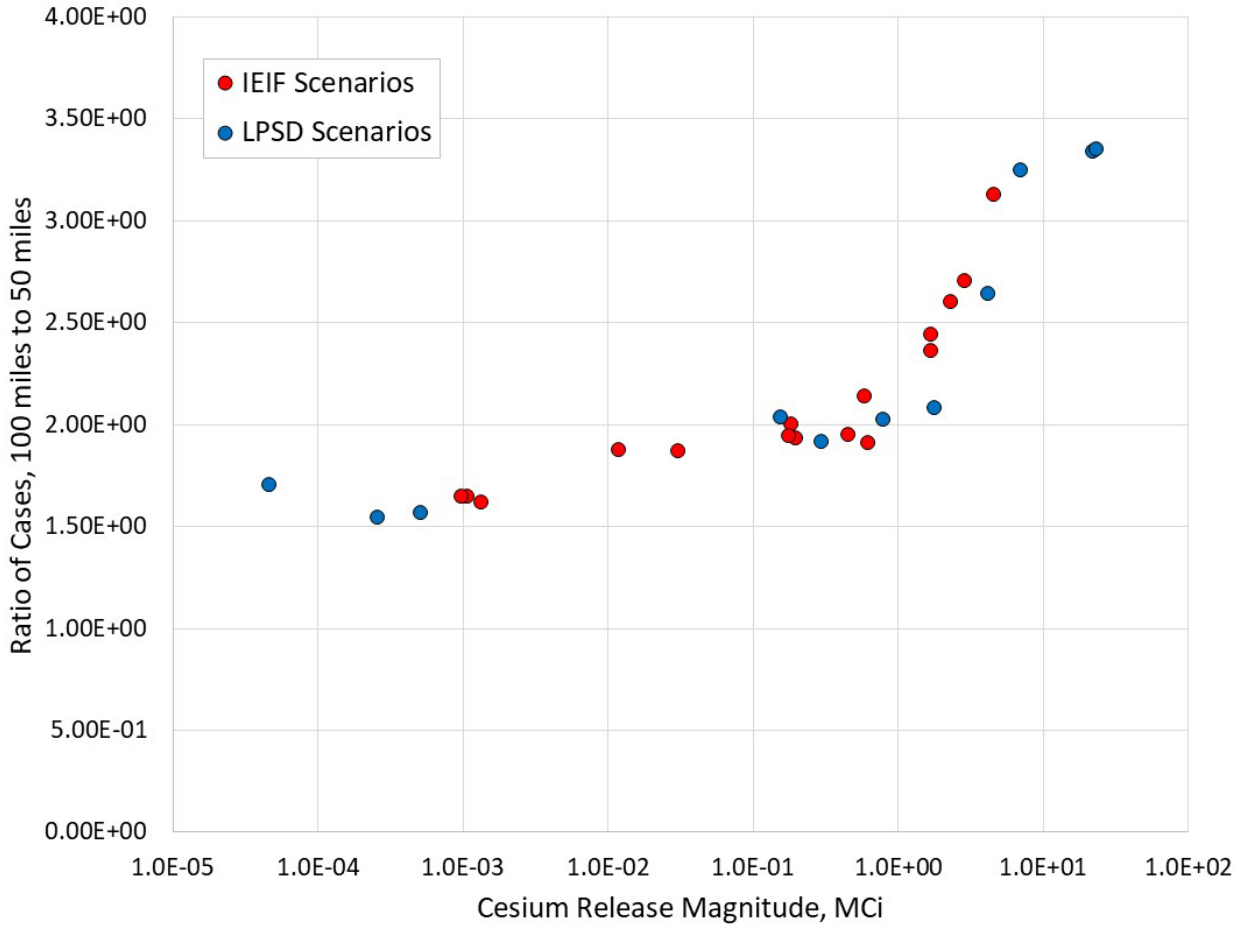
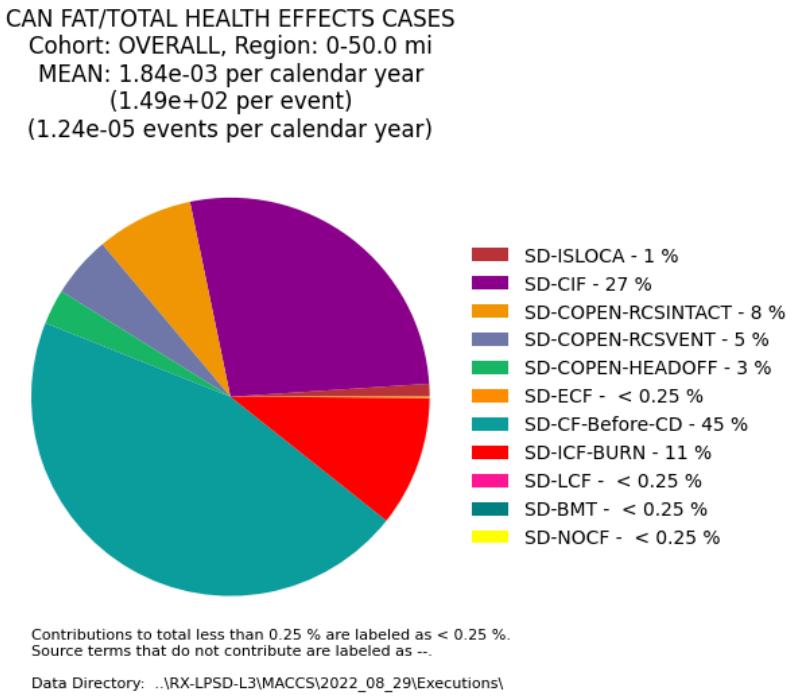


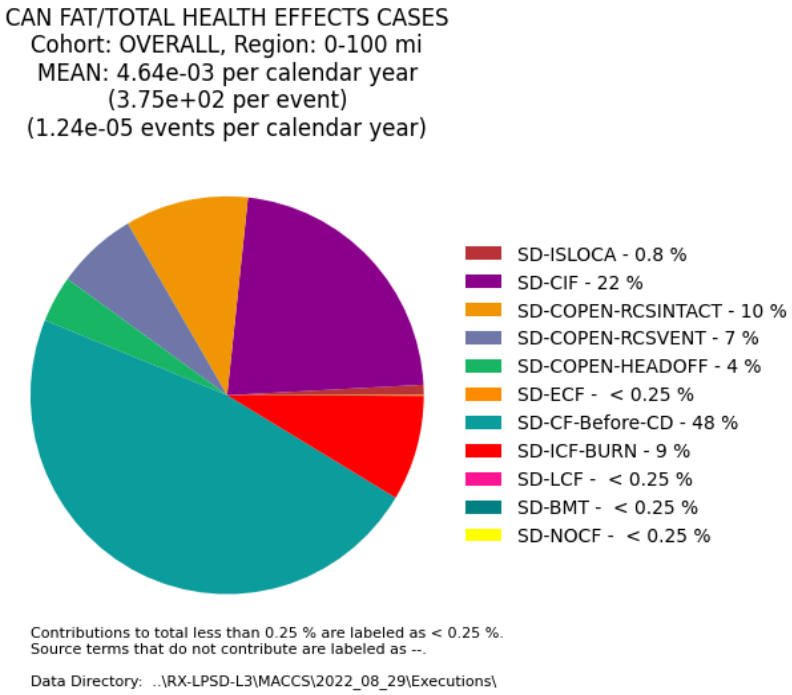
Figure 4-18 Ratio of Latent Fatality Cases Between 50 and 100 Miles as a Function of Cesium Release Magnitude

Figure 4-19 and Figure 4-20 show the contribution of individual release categories to the conditional mean value of total latent cancer fatalities within 50 and 100 miles, respectively. The risk arises largely from the CF-Before-CD and CIF release categories, with significant (greater than 5 percent) contributions from the COPEN-RCSINTACT, ICF-BURN, and COPEN-RCSVENT release categories. Although the relative contribution of release categories is broadly similar to that for the frequency-weighted release fractions (shown in Figure 3-1 and Figure 3-2), the relative ranking is different. This is most likely associated with the non-linearity in the relationship between cesium release magnitude and latent fatalities.



Note: CAN FAT/TOTAL: Total (across all cancer sites) latent fatalities

Figure 4-19 Contribution of Release Categories to Conditional Mean (Across All Weather Trials) Total Latent Fatality Cases within 50 Miles

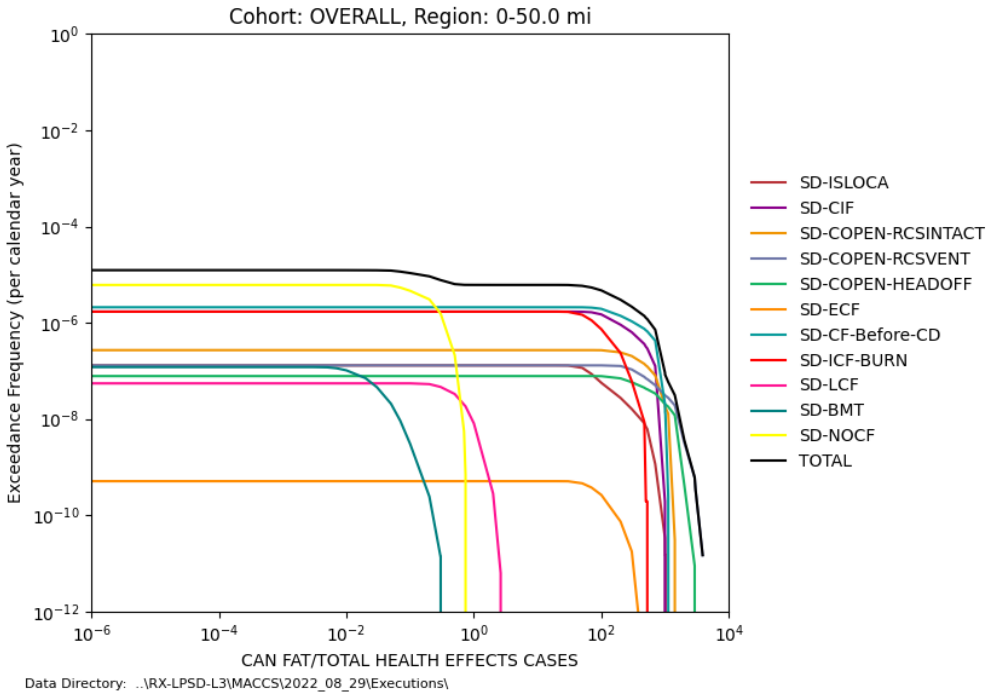


Note: CAN FAT/TOTAL: Total (across all cancer sites) latent fatalities

Figure 4-20 Contribution of Release Categories to Conditional Mean (Across All Weather Trials) Total Latent Fatality Cases within 100 Miles

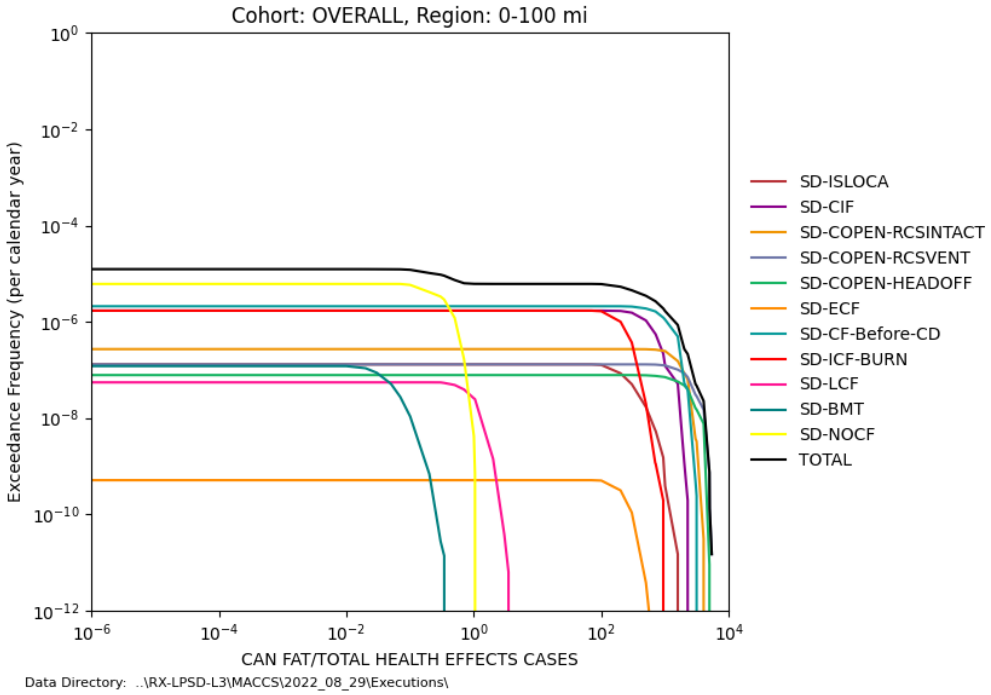
The relative contribution of different weather bins and release categories to the conditional mean value of the total latent fatality risk within 50 and 100 miles was also examined. Consistent with Section 4.3 of NRC (2022a), no pronounced difference in the relative contribution of release categories across different weather bins is particularly noticeable and the corresponding figures are therefore not reproduced here.

The previous discussion has focused on the conditional mean values across all weather trials. The CCDF provides information on the variability of the results because of weather conditions and different release categories. The CCDF curves for total latent fatality cases, for 0–50 miles and 0–100 miles, are shown in Figure 4-21 and Figure 4-22, respectively. Consistent with the previous discussion, release categories CF-Before-CD, CIF, and ICF-BURN (and at lower frequencies, COPEN-RCSVENT) appear to be the main contributors to the total number of latent fatalities.



Note: CAN FAT/TOTAL: Total (across all cancer sites) latent fatalities

Figure 4-21 Complementary Cumulative Distribution Function, Latent Fatality Cases, 0–50 Miles



Note: CAN FAT/TOTAL: Total (across all cancer sites) latent fatalities

Figure 4-22 Complementary Cumulative Distribution Function, Latent Fatality Cases, 0–100 Miles

4.3.2 Population-Weighted Individual Latent Fatality Risk (MACCS Type 8)

The conditional mean value of the Type 8 population-weighted individual latent cancer fatality risk within 10 miles is shown below by release category and cohort in Table 4-30. This result is obtained by dividing the total number of latent fatalities from direct exposures within the 10-mile region by the population residing within the 10-mile region. Latent fatalities arising from potential late-phase exposures to non-residential populations (i.e., from ingestion or to decontamination workers) are not included in this output; only direct exposure pathways (i.e., inhalation, cloudshine, and groundshine) are reflected in this output. Since, by definition, only those cohorts within 10 miles will contribute to the risk within 10 miles, only those cohorts are shown in Table 4-30. The fraction of population within 10 miles for each early-phase cohort and the release category frequency are also given in Table 4-30. Figure 4-23 illustrates the conditional mean results by release category and accident phase. Only three release categories (COPEN-RCSINTACT, COPEN-RCSVENT, and COPEN-HEADOFF) show a slight but noticeable (greater than 1 percent) early-phase contribution to the overall individual latent fatality risk. It is noticeable that the only release category with a warning time less than the EPZ clearance time (COPEN-RCSINTACT, with a warning time of 2 hours) is one of these release categories. For

all other release categories,[10] the warning times are sufficiently long that the non-evacuating cohort accounts for more than 90 percent of the total early-phase risk.

[10] Two exceptions are the extremely low-risk release categories BMT and NOCF, which have a total conditional early phase individual latent fatality risk less than 10^{-7} per-person per-event.

Table 4-30 Conditional Mean (Across All Weather Trials) Value of the Population-Weighted Individual Latent Cancer Fatality Risk within 10 Miles, by Release Category and Cohort

Release Category	1GP1 (18%)	1GP2 (18%)	1GP3 (18%)	1GPT (6.1%)	IND (38%)	NON-EVAC (0.3%)	EARLY (100%)	CHRONC (100%)	OVER ALL
ISLOCA	1.3E-07	1.3E-07	1.3E-07	1.3E-07	-	2.9E-04	9.4E-07	5.1E-04	5.1E-04
CIF	6.1E-08	6.1E-08	6.1E-08	6.1E-08	-	2.2E-04	6.8E-07	7.9E-04	7.9E-04
COPEN-RCSINTACT	2.7E-06	4.7E-06	1.9E-05	1.1E-04	3.2E-05	1.7E-03	2.9E-05	1.1E-03	1.1E-03
COPEN-RCSVENT	4.2E-06	4.2E-06	2.1E-05	4.7E-04	1.0E-04	1.0E-02	1.0E-04	8.6E-04	9.6E-04
COPEN-HEADOFF	1.9E-06	1.9E-06	1.9E-06	1.9E-06	-	5.3E-03	1.7E-05	9.9E-04	1.0E-03
ECF	5.5E-10	5.5E-10	5.5E-10	5.7E-10	1.7E-12	5.3E-05	1.6E-07	6.4E-04	6.4E-04
CF-Before-CD	1.5E-07	1.5E-07	1.5E-07	1.5E-07	-	5.1E-04	1.6E-06	8.6E-04	8.6E-04
ICF-BURN	2.5E-10	2.5E-10	2.5E-10	2.5E-10	3.8E-13	5.9E-05	1.8E-07	4.7E-04	4.7E-04
LCF	4.7E-11	4.7E-11	4.7E-11	6.5E-11	1.4E-12	1.4E-06	4.3E-09	8.0E-06	8.0E-06
BMT	2.4E-10	3.6E-10	9.0E-10	3.1E-09	1.2E-09	6.5E-08	1.1E-09	2.2E-07	2.2E-07
NOCF	6.0E-09	6.1E-09	6.5E-09	7.8E-09	2.5E-09	5.8E-08	5.0E-09	2.3E-06	2.3E-06

Notes:

1. *Fraction of population within 10 miles for each early-phase cohort given in parentheses.*
2. *Dashes represent MACCS results that are identically zero.*

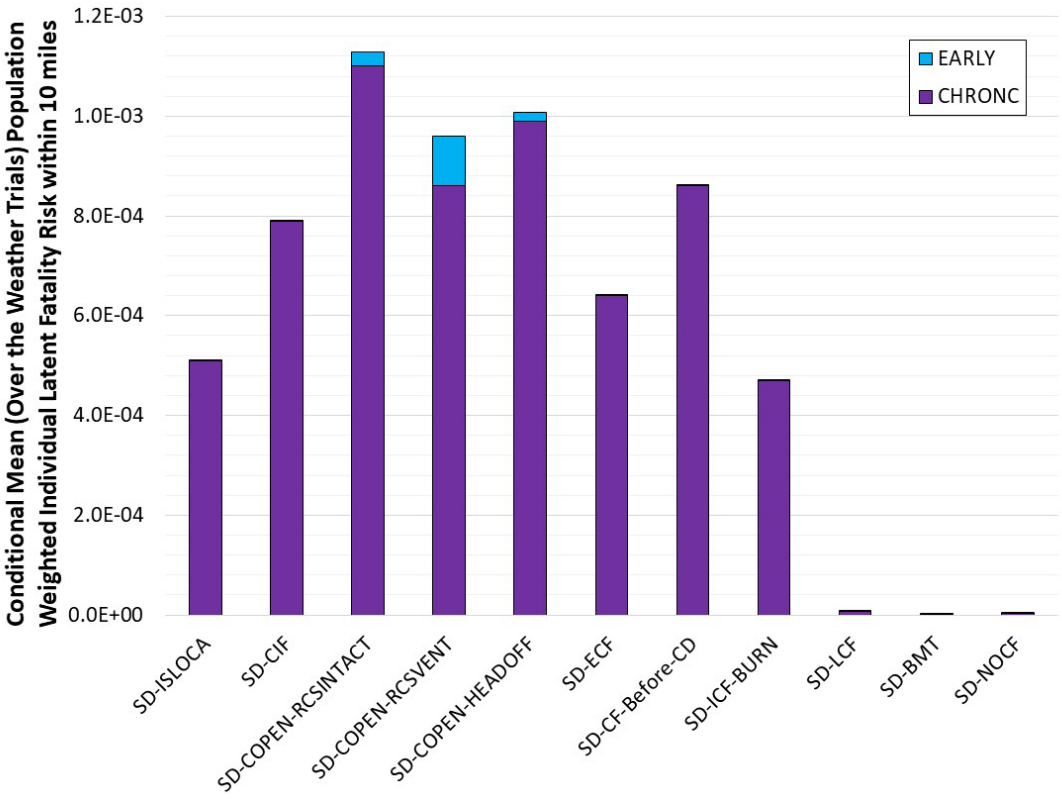


Figure 4-23 Conditional Mean (Across All Weather Trials) Population-Weighted Individual Latent Fatality Risk within 10 Miles by Release Category and Accident Phase

Figure 4-24 shows the conditional mean population-weighted individual latent fatality risk within 10 miles by accident phase as a function of cesium release magnitude. In Figure 4-24, the analogous results from the reactor, at-power, internal events and internal floods (IEIF) release categories are also shown for comparison. Figure 4-24 illustrates the extremely low early-phase individual latent fatality risk associated with LPSD release categories. This is consistent with examination of the results from Section 4.2 for early fatalities as well as the results from Section 4.1 showing very small populations subject to early-phase doses greater than 10 rem, both of which indicate very low early-phase exposure. It may also be noted that for comparable release magnitudes, the early-phase individual LCF risk from LPSD release categories is generally lower than that for the early-phase individual latent fatality risk from at-power release categories. This observation is consistent with the generally very long warning times associated with LPSD release categories. A final observation is that the non-linearity and apparent leveling off of the late-phase individual latent fatality risk for large releases (approximately greater than 10,000 Ci) is consistent across both LPSD scenarios and at-power scenarios. The late-phase risk is between 10^{-4} and 10^{-3} per-person per-event across almost three orders of magnitude of cesium release. The limited variation in the late-phase latent fatality risk is most likely associated with the effect of the late-phase habitability criteria defined by DSCRLT, which places an upper limit on the dose that can be received by an individual in the late phase.

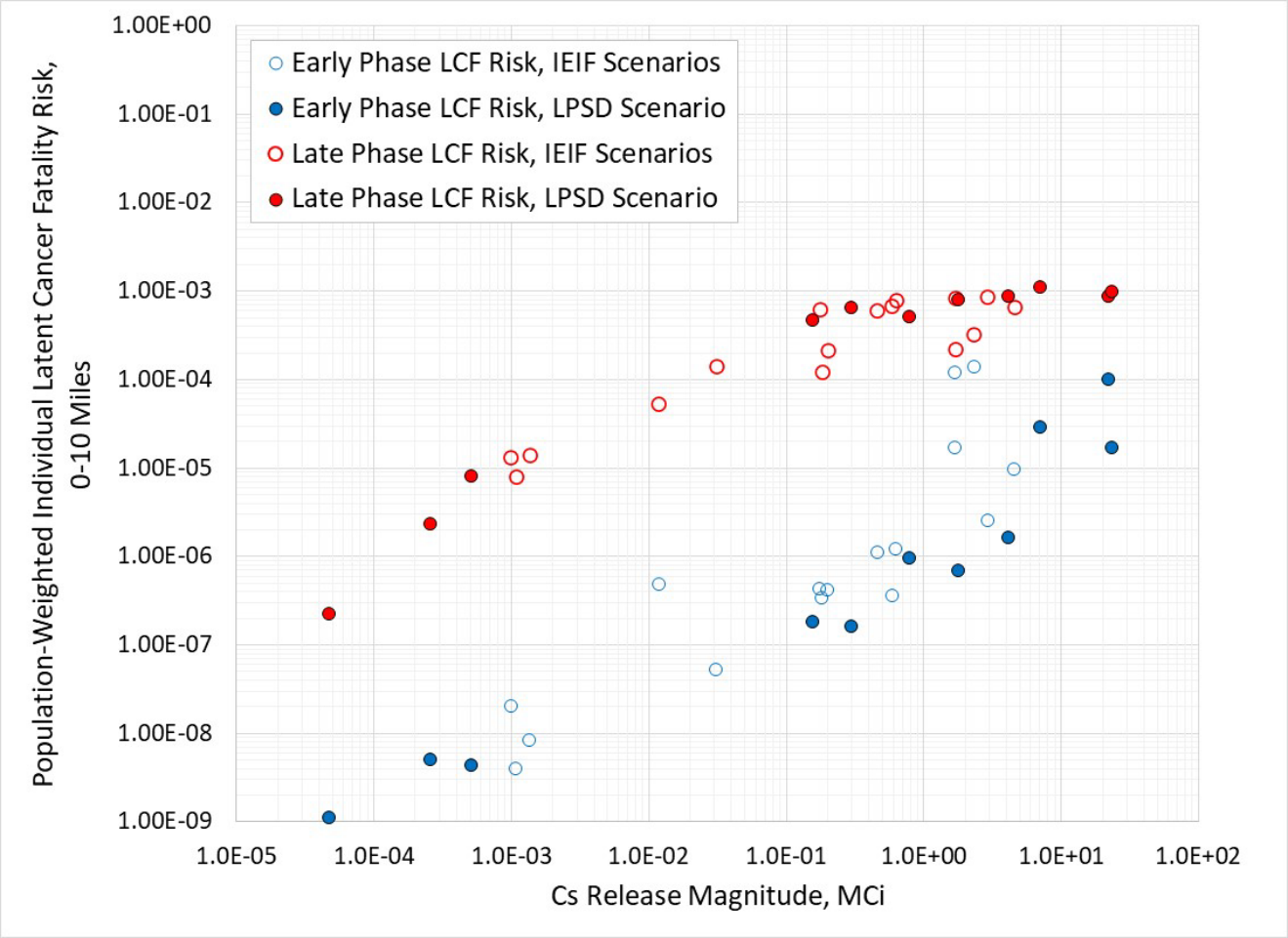
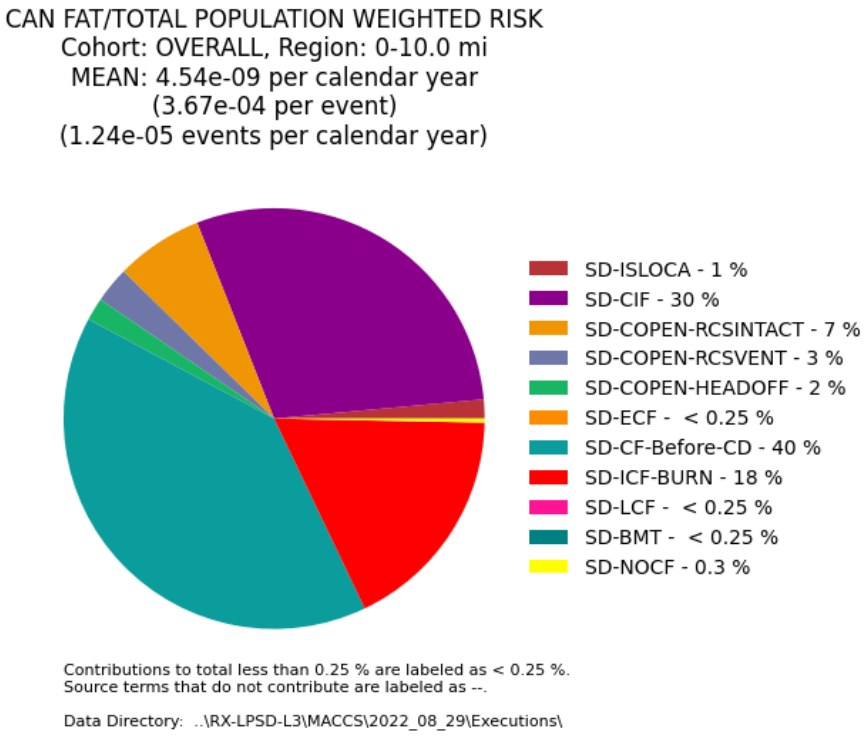


Figure 4-24 Conditional Mean (Across All Weather Trials) Early- and Late-Phase Population-Weighted Individual Latent Fatality Risk within 10 Miles as a Function of Cesium Release Magnitude

The relative contribution of the individual release categories to the overall conditional mean population-weighted individual latent fatality risk within 10 miles is shown in Figure 4-25. The relatively more frequent CF-Before-CD, CIF, and ICF-BURN release categories account for most of the mean value, together with a significant (7 percent) contribution from COPEN-RCSVENT. Despite being the most frequent release category, the NOCF release category contributes very little to the risk due to its very low conditional consequence. As was the case for total latent fatality cases shown in Figure 4-19 and Figure 4-20, these relative contributions are relatively similar to the relative contributions of release categories to the frequency-weighted total release fractions shown in Figure 3-1 and Figure 3-2. The relative unimportance of the COPEN-RCSVENT and COPEN-HEADOFF release categories (4 percent of the frequency-weighted individual LCF risk versus 25 percent of the frequency-weighted cesium release magnitude risk) is most likely due to the non-linearity in the relationship between release magnitude and individual latent fatality risk seen in Figure 4-24. That is, although the COPEN-RCSVENT and COPEN-HEADOFF release categories have release magnitudes that are over 130 times larger than that of the ICF-BURN release category, the conditional individual latent fatality risks are only approximately twice as large.



Note: CAN FAT/TOTAL: Total (across all cancer sites) latent fatality risk

Figure 4-25 Relative Contribution of the Individual Release Categories to Conditional Mean (Across All Weather Trials) Population-Weighted Individual Latent Fatality Risk within 10 Miles

The relative contribution of different weather bins and release categories to the conditional mean value of the individual latent fatality risk was also examined. Consistent with Section 4.3 of NRC (2022a), no pronounced difference in the relative contribution of release categories across different weather bins is particularly noticeable and the corresponding figures are therefore not reproduced here.

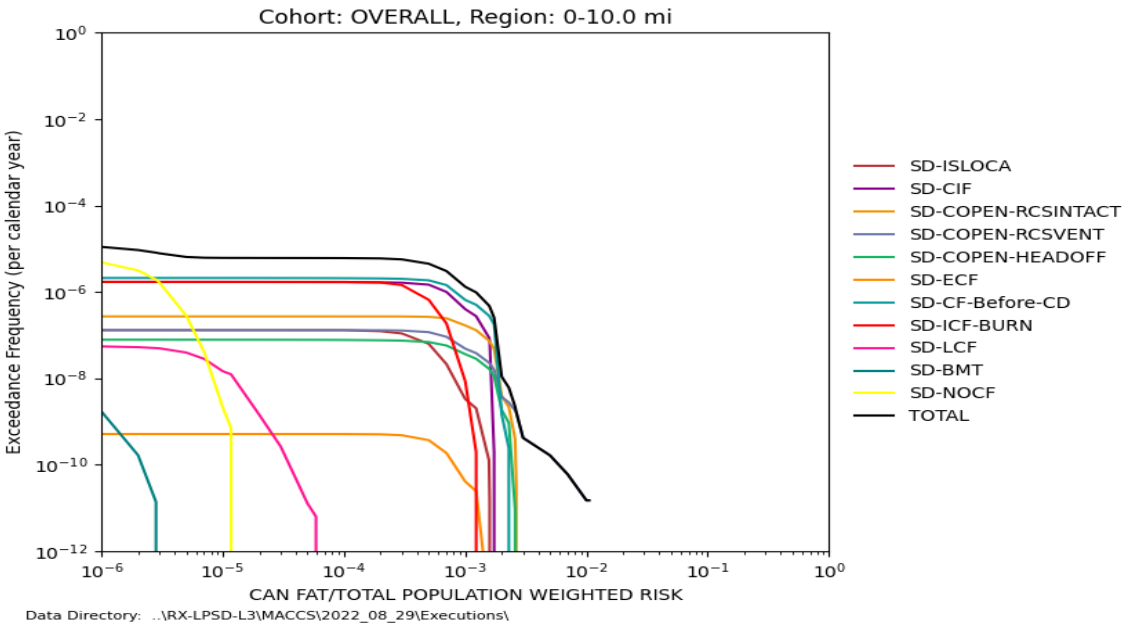
The CCDF curves for the population-weighted individual latent fatality risk are shown in Figure 4-26. A sharp drop in the frequency of exceeding an individual latent fatality risk of approximately 10^{-3} (0.1 percent) per event can be seen in the graph. Inspection of intermediate results, as shown in Figure 4-27 and Figure 4-28, shows that this is driven by the CCDF for the late phase, which drops abruptly at this consequence level. This demonstrates that weather conditions do not drive individual risk levels higher than this for the late phase.

The frequency-weighted contribution of individual cohorts to the total 0–10 mile individual (population-weighted) latent cancer fatality risk may also be examined to identify which cohorts may be most at risk, and which cohorts contribute the most to the overall CCDF when accounting for their relative size. Figure 4-27 presents CCDF curves for the frequency-weighted total cancer fatality population-weighted risk for cohorts located within the 0–10-mile EPZ. These curves are weighted by the release category frequency but not by the cohort's fraction of the 0–10-mile EPZ population. Figure 4-28 presents CCDF curves for the frequency-weighted total cancer fatality population-weighted risk for cohorts located within the 0–10-mile EPZ. These curves are weighted by both the release category frequency and the cohort's fraction of

the 0–10-mile EPZ population. The sum of the curves (1GP1, 1GP2, 1GP3, 1GPT, IND, and CHRONC) in Figure 4-28 should reflect the overall population-weighted total cancer fatality risk within the 0–10-mile EPZ. Several insights may be drawn from these figures:

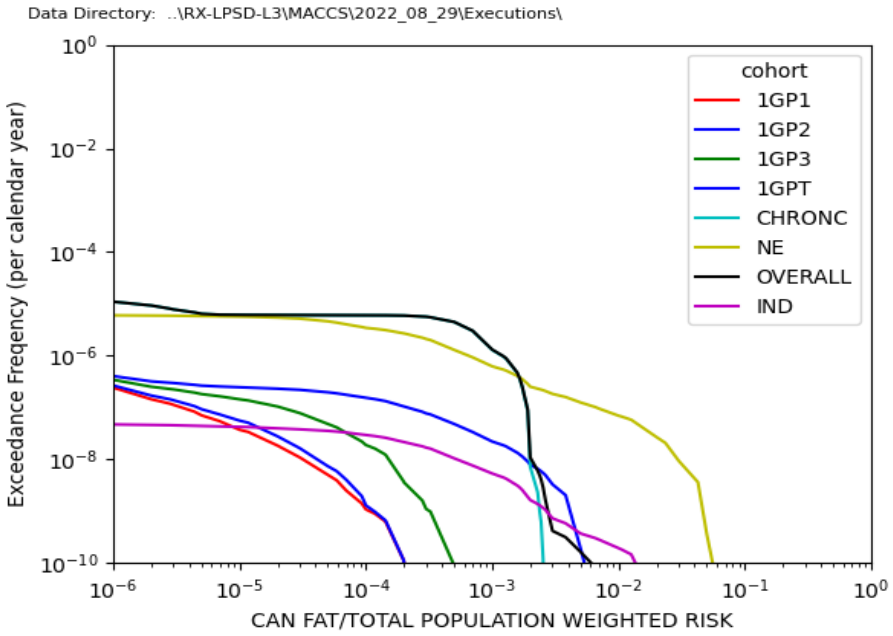
- The risk is primarily associated with the long-term (CHRONC) exposures, not the early-phase exposures. As seen in Figure 4-27, the CHRONC cohort bounds all early-phase cohorts at an exceedance frequency of 10^{-6} per calendar-year or greater. When the likelihood of an individual being in a particular early-phase cohort is taken into consideration (i.e., Figure 4-28), the CHRONC cohort bounds all early-phase cohorts at all exceedance frequency levels.

- Figure 4-28 demonstrates that, consistent with the at-power release categories, the early-phase risks at low frequency levels are dominated by the IND cohort, not the non-evacuating or evacuation tail cohorts. Even though this cohort is located almost 10 miles away from the point of release, it still comprises 38 percent of the total 0–10-mile population. In contrast, the general public evacuation tail comprises only 6.1 percent of the total 0–10-mile population, and the non-evacuating cohort comprises only 0.3 percent of the total 0–10-mile population. It is also subject to a longer evacuation time than the 10-mile general public, with an evacuation time (DLTSHL + DLTEVA + DURBEG + DURMID) of 3.75 hours, slightly longer than the 3.34 hours for the 0–10-mile tail cohort. These low relative populations result in a small contribution to the overall risk, despite the similar or higher conditional risks.



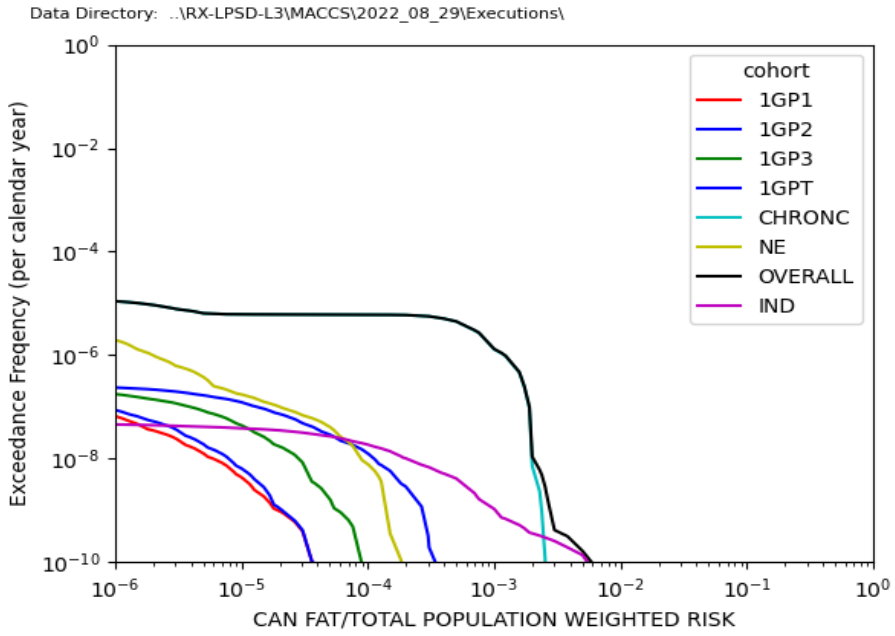
Note: CAN FAT/TOTAL: Total (across all cancer sites) latent fatality risk

Figure 4-26 Complementary Cumulative Distribution Function, Population-Weighted Individual Latent Fatality Risk within 10 Miles



Note: CAN FAT/TOTAL: Total (across all cancer sites) latent fatality risk

Figure 4-27 Complementary Cumulative Distribution Function, Population-Weighted Individual Latent Fatality Risk within 10 Miles: Frequency-Weighted for Each Source Term and Population-Weighted by Individual Cohort Populations



Note: CAN FAT/TOTAL: Total (across all cancer sites) latent fatality risk

Figure 4-28 Complementary Cumulative Distribution Function, Population-Weighted Individual Latent Fatality Risk within 10 Miles: Frequency-Weighted for Each Source Term and Population-Weighted by All Cohort Populations

4.3.3 Sensitivity Cases

4.3.3.1 Meteorological Sampling

The effect of sampling only a subset of the meteorological data on the individual latent fatality risk within 16 km (10 mi), as well as on the projected total number of latent fatality cases within 80 and 161 km (50 and 100 mi) is demonstrated in Table 4-31, Table 4-32, and Table 4-33. It is evident from inspection of these results that differences resulting from sampling a representative subset of weather trials as opposed to sampling all 8,760 hourly observations are generally less than a few percent.

Table 4-31 Population-Weighted Individual Latent Fatality Risk, 0–10 Miles (Conditional Mean Value Across All Weather Trials): ME_2

Release Category	Frequency (/yr)	Base Case	ME_2	Fraction of Base Case[2]
ALL[1] (per yr)	**1.2E-05**	**4.5E-09**	**4.5E-09**	**1.001**
ISLOCA	1.3E-07	5.1E-04	5.0E-04	0.988
CIF	1.7E-06	7.9E-04	7.8E-04	0.995
COPEN-RCSINTACT	2.7E-07	1.1E-03	1.1E-03	0.982
COPEN-RCSVENT	1.3E-07	9.6E-04	9.5E-04	0.983
COPEN-HEADOFF	7.8E-08	1.0E-03	9.9E-04	0.984
ECF	5.1E-10	6.4E-04	6.4E-04	0.991
CF-Before-CD	2.1E-06	8.6E-04	8.7E-04	1.009
ICF-BURN	1.7E-06	4.7E-04	4.7E-04	1.004
LCF	5.5E-08	8.0E-06	7.9E-06	0.991
BMT	1.2E-07	2.2E-07	2.2E-07	1.009
NOCF	6.1E-06	2.3E-06	2.3E-06	1.018

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of base case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded base case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Table 4-32 Total Latent Fatality Cases, 0–50 Miles (Conditional Mean Value Across All Weather Trials): ME_2

Release Category	Frequency (/yr)	Base Case	ME_2	Fraction of Base Case[2]
ALL[1] (per yr)	**1.2E-05**	**1.8E-03**	**1.8E-03**	**0.980**
ISLOCA	1.3E-07	1.5E+02	1.5E+02	0.980
CIF	1.7E-06	3.0E+02	2.9E+02	0.980
COPEN-RCSINTACT	2.7E-07	5.4E+02	5.3E+02	0.979
COPEN-RCSVENT	1.3E-07	7.1E+02	7.1E+02	0.994
COPEN-HEADOFF	7.8E-08	6.7E+02	6.7E+02	0.996
ECF	5.1E-10	1.2E+02	1.2E+02	1.000
CF-Before-CD	2.1E-06	4.0E+02	3.9E+02	0.970
ICF-BURN	1.7E-06	1.2E+02	1.2E+02	1.017
LCF	5.5E-08	6.5E-01	6.5E-01	1.009
BMT	1.2E-07	3.2E-02	3.1E-02	0.997
NOCF	6.1E-06	2.2E-01	2.2E-01	1.018

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of base case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded base case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Table 4-33 Total Latent Fatality Cases, 0–100 Miles (Conditional Mean Value Across All Weather Trials): ME_2

Release Category	Frequency (/yr)	Base Case	ME_2	Fraction of Base Case[2]
ALL[1] (per yr)	**1.2E-05**	**4.6E-03**	**4.6E-03**	**0.994**
ISLOCA	1.3E-07	3.0E+02	3.0E+02	0.997
CIF	1.7E-06	6.1E+02	6.1E+02	0.993
COPEN-RCSINTACT	2.7E-07	1.7E+03	1.7E+03	0.994
COPEN-RCSVENT	1.3E-07	2.4E+03	2.4E+03	1.000
COPEN-HEADOFF	7.8E-08	2.3E+03	2.3E+03	1.000
ECF	5.1E-10	2.4E+02	2.4E+02	1.004
CF-Before-CD	2.1E-06	1.1E+03	1.0E+03	0.990
ICF-BURN	1.7E-06	2.3E+02	2.4E+02	1.004
LCF	5.5E-08	1.0E+00	1.0E+00	1.010
BMT	1.2E-07	5.4E-02	5.3E-02	0.994
NOCF	6.1E-06	3.4E-01	3.4E-01	1.015

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of base case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded base case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

4.3.3.2 Accident Termination Time

The effect of terminating the accident release 36 hours after SAMG entry on the individual latent fatality risk, as well as on the total latent fatality cases within 80 and 161 km (50 and 100 mi), is demonstrated in Table 4-34, Table 4-35, and Table 4-36. For sensitivity analysis, only a subset of weather trials was sampled to increase computational efficiency. For this case, the reference case values are therefore the results from ME_2 described in the previous section. These values were selected for the reference case to minimize confounding effects from weather sampling with the effect of accident termination time.

The effect of terminating the release is a reduction in the latent fatality risk. On a frequency-weighted basis, the reduction is approximately a factor of 10–25 percent. Most release categories are only modestly affected, with a reduction on the order of a 10–20 percent, whereas some release categories (such as the ECF and ICF-BURN release categories) are reduced by over 99 percent.

The differential impact of the accident termination time on the relative contribution of release categories to the individual latent fatality risk is illustrated in Figure 4-29. The frequency-weighted reduction in the individual latent cancer fatality risk is a combination of the much lower conditional consequences for the ICF release category with a noticeable (greater than 10 percent) reduction in the conditional consequences for the COPEN-RCSVENT and COPEN-RCSINTACT release categories. The relative contribution of release categories to the individual latent cancer fatality risk is similar to the relative contribution of release categories to the cumulative cesium release shown in Figure 4-1, with the CIF and CF-Before-CD release categories increasing slightly in relative importance and the ICF release category comprising a much smaller contributor.

Table 4-34 Population-Weighted Individual Latent Fatality Risk, 0–10 Miles (Conditional Mean Value Across All Weather Trials): RE_4

Release Category	Frequency (/yr)	Reference Case (ME_2)	RE_4	Fraction of Reference Case[2]
ALL[1] (per yr)	**1.2E-05**	**4.5E-09**	**3.5E-09**	**0.773**
ISLOCA	1.3E-07	5.0E-04	3.9E-04	0.777
CIF	1.7E-06	7.8E-04	7.6E-04	0.963
COPEN-RCSINTACT	2.7E-07	1.1E-03	8.2E-04	0.741
COPEN-RCSVENT	1.3E-07	9.5E-04	6.7E-04	0.704
COPEN-HEADOFF	7.8E-08	9.9E-04	8.9E-04	0.896
ECF	5.1E-10	6.4E-04	1.5E-05	0.024
CF-Before-CD	2.1E-06	8.7E-04	8.5E-04	0.975
ICF-BURN	1.7E-06	4.7E-04	2.8E-06	0.006
LCF	5.5E-08	7.9E-06	2.7E-06	0.338
BMT	1.2E-07	2.2E-07	1.8E-07	0.836
NOCF	6.1E-06	2.3E-06	2.1E-06	0.900

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of reference case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded reference case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Table 4-35 Total Latent Fatality Cases, 0–50 Miles (Conditional Mean Value Across All Weather Trials): RE_4

Release Category	Frequency (/yr)	Reference Case (ME_2)	RE_4	Fraction of Reference Case[2]
ALL[1] (per yr)	**1.2E-05**	**1.8E-03**	**1.6E-03**	**0.858**
ISLOCA	1.3E-07	1.5E+02	1.3E+02	0.918
CIF	1.7E-06	2.9E+02	2.9E+02	0.986
COPEN-RCSINTACT	2.7E-07	5.3E+02	4.1E+02	0.787
COPEN-RCSVENT	1.3E-07	7.1E+02	6.1E+02	0.870
COPEN-HEADOFF	7.8E-08	6.7E+02	6.5E+02	0.972
ECF	5.1E-10	1.2E+02	1.8E+00	0.014
CF-Before-CD	2.1E-06	3.9E+02	3.8E+02	0.992
ICF-BURN	1.7E-06	1.2E+02	2.7E-01	0.002
LCF	5.5E-08	6.5E-01	2.8E-01	0.425
BMT	1.2E-07	3.1E-02	2.6E-02	0.825
NOCF	6.1E-06	2.2E-01	2.0E-01	0.897

1. Results are a frequency-weighted sum of all release categories.

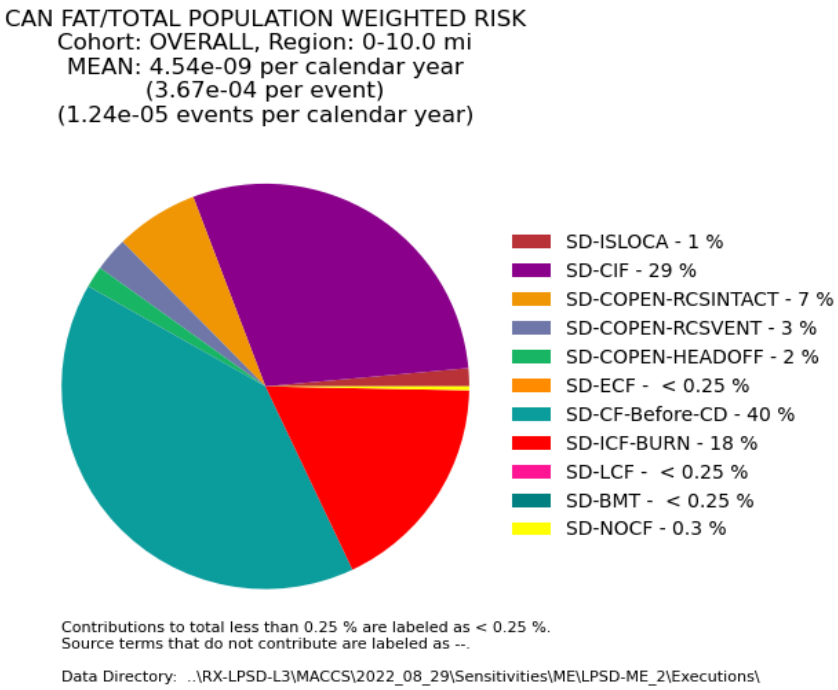
2. Fraction of reference case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded reference case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Table 4-36 Total Latent Fatality Cases, 0–100 Miles (Conditional Mean Value Across All Weather Trials): RE_4

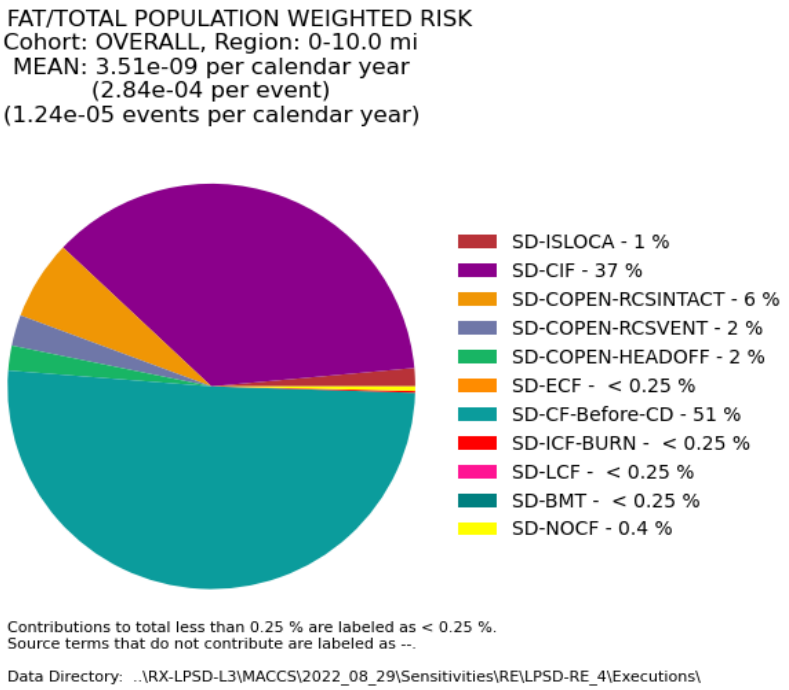
Release Category	Frequency (/yr)	Reference Case (ME_2)	RE_4	Fraction of Reference Case[2]
ALL[1] (per yr)	**1.2E-05**	**4.6E-03**	**4.0E-03**	**0.870**
ISLOCA	1.3E-07	3.0E+02	2.8E+02	0.927
CIF	1.7E-06	6.1E+02	6.0E+02	0.987
COPEN-RCSINTACT	2.7E-07	1.7E+03	1.3E+03	0.746
COPEN-RCSVENT	1.3E-07	2.4E+03	2.1E+03	0.865
COPEN-HEADOFF	7.8E-08	2.3E+03	2.2E+03	0.982
ECF	5.1E-10	2.4E+02	3.3E+00	0.014
CF-Before-CD	2.1E-06	1.0E+03	1.0E+03	0.990
ICF-BURN	1.7E-06	2.4E+02	4.1E-01	0.002
LCF	5.5E-08	1.0E+00	4.3E-01	0.424
BMT	1.2E-07	5.3E-02	4.3E-02	0.816
NOCF	6.1E-06	3.4E-01	3.1E-01	0.895

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of reference case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded reference case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.



Reference Case (ME_2)



RE_4

Figure 4-29 Relative Contribution of Release Categories to Population-Weighted Individual Latent Fatality Risk within 10 Miles: RE_4

4.3.3.3 Low-Dose Cancer Risk Estimation

The effect of a model that estimates cancer risk based only on annual individual doses greater than 0.05 Sv (5 rem) or lifetime individual doses greater than 0.1 Sv (10 rem) on the individual latent fatality risk, as well as on the total latent fatality cases within 80 and 161 km (50 and 100 mi), is demonstrated in Table 4-37, Table 4-38, and Table 4-39. For sensitivity analysis, only a subset of weather trials was sampled to increase computational efficiency. For this case, the reference case values are therefore the results from ME_2 described previously. These values were selected for the reference case to minimize confounding effects from weather sampling with the effect of accident termination time.

As expected, there is a significant difference in estimated latent health effect risks arising from the use of a model that estimates cancer risk based only on annual individual doses greater than 0.05 Sv (5 rem), or lifetime individual doses greater than 0.1 Sv (10 rem). The overall frequency-weighted risk drops by over two orders of magnitude, and the calculated risk from many release categories is reduced by three orders of magnitude or more. However, the COPEN release categories that had exhibited a noticeable early-phase contribution (as illustrated in Figure 4-23) exhibit a much lower reduction, albeit still significant (a factor of 5–100).

The differential impact of the alternate cancer risk model on the relative contribution of release categories to the individual latent fatality risk is illustrated in Figure 4-30. The COPEN release categories, and in particular the COPEN-RCSVENT release category, dominate the reduced estimated risk. The relative contribution of release categories to latent fatality risk in this sensitivity analysis is consistent with the relative contribution of release categories to early health risk which were dominated by the COPEN-RCSVENT release category, with minor contributions from the other COPEN release categories. This lends further support to the observation that most accidents initiated during LPSD operations resulting in core damage do not result in high individual doses at the reference site because of effective early-phase protective actions. Only the relatively infrequent events that exhibit low warning times coupled with large releases are likely to result in elevated doses at the reference site.

Table 4-37 Population-Weighted Individual Latent Fatality Risk, 0–10 Miles (Conditional Mean Value Across All Weather Trials): HE_2

Release Category	Frequency (/yr)	Reference Case (ME_2)	HE_2	Fraction of Reference Case[2]
ALL[1] (per yr)	**1.2E-05**	**4.5E-09**	**2.0E-11**	**0.004**
ISLOCA	1.3E-07	5.0E-04	5.2E-07	0.001
CIF	1.7E-06	7.8E-04	2.6E-07	0.000
COPEN-RCSINTACT	2.7E-07	1.1E-03	1.5E-05	0.014
COPEN-RCSVENT	1.3E-07	9.5E-04	8.9E-05	0.094
COPEN-HEADOFF	7.8E-08	9.9E-04	1.7E-05	0.017
ECF	5.1E-10	6.4E-04	3.0E-09	0.000
CF-Before-CD	2.1E-06	8.7E-04	1.3E-06	0.001
ICF-BURN	1.7E-06	4.7E-04	4.5E-09	0.000
LCF	5.5E-08	7.9E-06	-	-
BMT	1.2E-07	2.2E-07	-	-
NOCF	6.1E-06	2.3E-06	-	-

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of reference case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded reference case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.

Table 4-38 Total Latent Fatality Cases, 0–50 Miles (Conditional Mean Value Across All Weather Trials): HE_2

Release Category	Frequency (/yr)	Reference Case (ME_2)	HE_2	Fraction of Reference Case[2]
ALL[1] (per yr)	**1.2E-05**	**1.8E-03**	**2.8E-05**	**0.016**
ISLOCA	1.3E-07	1.5E+02	1.6E-01	0.001
CIF	1.7E-06	2.9E+02	1.6E-01	0.001
COPEN-RCSINTACT	2.7E-07	5.3E+02	8.6E+00	0.016
COPEN-RCSVENT	1.3E-07	7.1E+02	1.5E+02	0.208
COPEN-HEADOFF	7.8E-08	6.7E+02	6.4E+01	0.095
ECF	5.1E-10	1.2E+02	1.6E-01	0.001
CF-Before-CD	2.1E-06	3.9E+02	5.1E-01	0.001
ICF-BURN	1.7E-06	1.2E+02	1.6E-01	0.001
LCF	5.5E-08	6.5E-01	7.7E-04	0.001
BMT	1.2E-07	3.1E-02	7.5E-06	0.000
NOCF	6.1E-06	2.2E-01	2.7E-04	0.001

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of reference case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded reference case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.

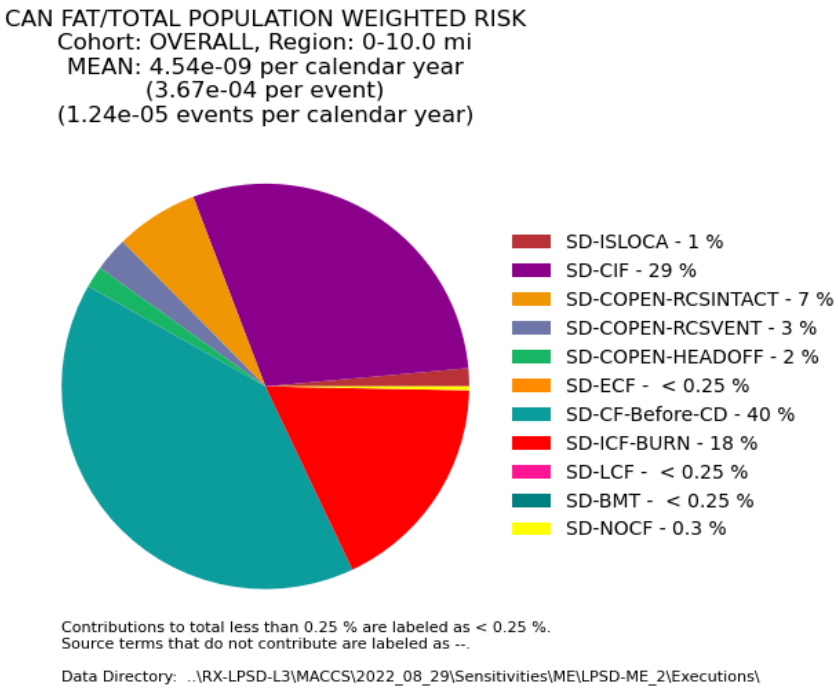
Table 4-39 Total Latent Fatality Cases, 0–100 Miles (Conditional Mean Value Across All Weather Trials): HE_2

Release Category	Frequency (/yr)	Reference Case (ME_2)	HE_2	Fraction of Reference Case[2]
ALL[1] (per yr)	**1.2E-05**	**4.6E-03**	**2.9E-05**	**0.006**
ISLOCA	1.3E-07	3.0E+02	1.6E-01	0.001
CIF	1.7E-06	6.1E+02	1.6E-01	0.000
COPEN-RCSINTACT	2.7E-07	1.7E+03	9.1E+00	0.005
COPEN-RCSVENT	1.3E-07	2.4E+03	1.5E+02	0.065
COPEN-HEADOFF	7.8E-08	2.3E+03	6.6E+01	0.029
ECF	5.1E-10	2.4E+02	1.6E-01	0.001
CF-Before-CD	2.1E-06	1.0E+03	5.1E-01	0.000
ICF-BURN	1.7E-06	2.4E+02	1.6E-01	0.001
LCF	5.5E-08	1.0E+00	7.7E-04	0.001
BMT	1.2E-07	5.3E-02	7.5E-06	0.000
NOCF	6.1E-06	3.4E-01	2.7E-04	0.001

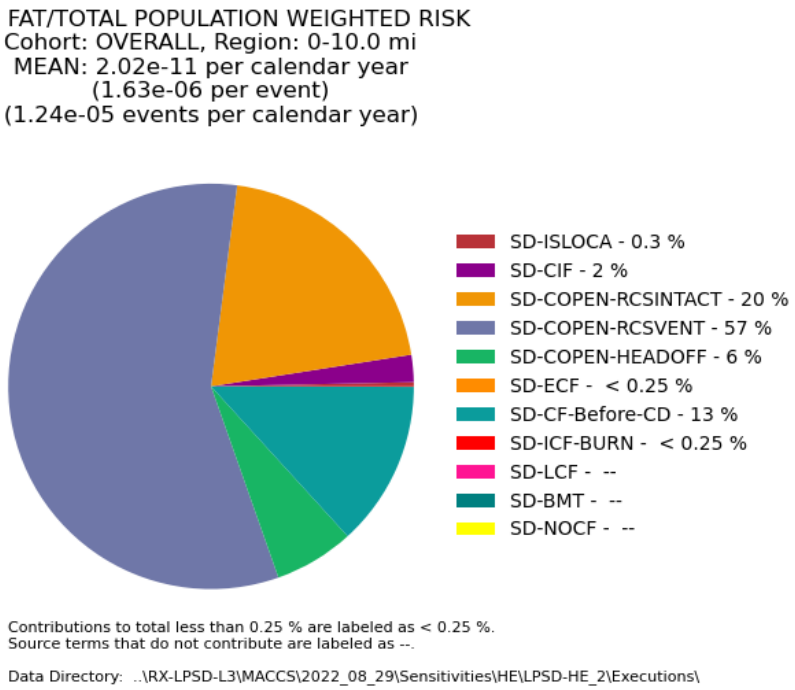
1. Results are a frequency-weighted sum of all release categories.

2. Fraction of reference case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded reference case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.



Reference Case (ME_2)



HE_2

Figure 4-30 Relative Contribution of Release Categories to Population-Weighted Individual Latent Fatality Risk within 10 Miles: HE_2

4.4 Land Contamination

The following discussion is adapted from Section 4.4 of NRC (2022a) and is modified to discuss the effect of the different release category characteristics associated with the LPSD analysis documented in NRC (2025). Land contamination may be characterized either in terms of how much land would exceed a specified radionuclide deposition level (MACCS Type D output, Table 4-40 and Table 4-41) or how much land is projected to be subject to different types of protective actions (MACCS Type 12 output, Table 4-42 and Table 4-43). Consistent with Section 4.4 of NRC (2022a), examination of Table 4-40 and Table 4-41 shows that the absolute value of a land contamination measure based on Cs-137 deposition is sensitive to the deposition level chosen as a threshold. A level of 555 kBq/m^2 (15 Ci/km^2) is chosen for further examination as that level is likely to require some level of restriction during the intermediate and recovery phases. As discussed in Annex I of IAEA (2001), this value was chosen following the Chernobyl accident as a level at which the population was relocated. It should be noted that this does not imply that relocation would be projected in MACCS at this deposition level. This is simply chosen as a benchmark level of land contamination.

Table 4-40 Conditional Mean (Across All Weather Trials) Land Area (mi^2) Exceeding Cs-137 Deposition Levels within 50 Miles of the Site

Release Category	Frequency (/yr)	Cs-137 Deposition > 1 Ci/km^2	Cs-137 Deposition > 5 Ci/km^2	Cs-137 Deposition > 15 Ci/km^2	Cs-137 Deposition > 40 Ci/km^2
ISLOCA	1.3E-07	1900	830	320	110
CIF	1.7E-06	3700	1900	830	300
COPEN-RCSINTACT	2.7E-07	5000	2900	1800	930
COPEN-RCSVENT	1.3E-07	3700	2800	2300	1700
COPEN-HEADOFF	7.8E-08	4700	3600	2800	1900
ECF	5.1E-10	1600	310	100	36
CF-Before-CD	2.1E-06	3900	2600	1600	710
ICF-BURN	1.7E-06	760	140	43	15
LCF	5.5E-08	3.7	0.65	0.17	0.046
BMT	1.2E-07	0.048	0.0022	8.8E-06	-
NOCF	6.1E-06	2	0.33	0.083	0.019

Note: Dashes represent MACCS results that are identically zero.

Table 4-41 Conditional Mean (Across All Weather Trials) Land Area (mi^2) Exceeding Cs-137 Deposition Levels within 100 Miles of the Site

Release Category	Frequency (/yr)	Cs-137 Deposition >1 Ci/km^2	Cs-137 Deposition >5 Ci/km^2	Cs-137 Deposition >15 Ci/km^2	Cs-137 Deposition >40 Ci/km^2
ISLOCA	1.3E-07	4300	1100	330	120
CIF	1.7E-06	9400	2900	880	300
COPEN-RCSINTACT	2.7E-07	14000	7100	3200	1200
COPEN-RCSVENT	1.3E-07	12000	9400	6700	3900
COPEN-HEADOFF	7.8E-08	16000	12000	7500	3900
ECF	5.1E-10	1900	310	100	36
CF-Before-CD	2.1E-06	12000	5800	2300	760
ICF-BURN	1.7E-06	780	140	43	15
LCF	5.5E-08	3.7	0.65	0.17	0.046
BMT	1.2E-07	0.048	0.0022	0.0000088	-
NOCF	6.1E-06	2	0.33	0.083	0.019

Note: Dashes represent MACCS results that are identically zero.

Table 4-42 shows the areal extent of agricultural restrictions that would be expected in the year of the accident, such as crop or milk disposal, as well as longer term restrictions, such as interdiction or condemnation. Values are given for the conditional mean affected areas within 100 miles. Consistent with Section 4.4 of NRC (2022a), examination of Table 4-42 shows the areal extent of agricultural restrictions is likely to be the highest in the year of the accident, although some level of interdiction may be necessary in following years. However, comparison of the interdicted to condemned land shows that most land initially subject to agricultural restrictions may eventually be recovered as natural weathering and radioactive decay reduce doses to levels below the interdiction criteria. It should be noted that the agricultural interdiction criteria used in this analysis (DOSEMILK, DOSEOTHER, and DOSELONG) are set low enough to ensure that the more restrictive child dose levels are not exceeded. All else being equal, more restrictive agricultural interdiction criteria will reduce collective doses from ingestion but will result in larger areas projected to be subject to agricultural restrictions. Also of interest is the fact that no farmland is projected to be decontaminated in this analysis. This is believed to be due to the updated decontamination cost parameters (CDFRM) that include the cost of waste disposal. The high disposal costs associated with removal and disposal of contaminated farmland soil, coupled with the relatively low per hectare value of farmland (VALWF), may cause the MACCS code to project condemnation or interdiction rather than decontamination efforts on farmland because the cost of decontamination would exceed the property value of the land.

Table 4-42 Conditional Mean Land Area (mi^2) within 100 Miles Subject to Agricultural Restrictions

Release Category	Frequency (/yr)	Crop Disposal	Milk Disposal	Decontamination	Inter-diction	Condemnation
ISLOCA	1.3E-07	1800	3300	-	1700	64
CIF	1.7E-06	2800	3300	-	2600	170
COPEN-RCSINTACT	2.7E-07	4400	5300	-	3800	640
COPEN-RCSVENT	1.3E-07	3700	4400	-	2100	1600
COPEN-HEADOFF	7.8E-08	4400	5000	-	2700	1700
ECF	5.1E-10	1500	3000	-	1500	21
CF-Before-CD	2.1E-06	3300	3800	-	2800	430
ICF-BURN	1.7E-06	890	2900	-	880	9
LCF	5.5E-08	2.6	5.6	-	2.6	0.045
BMT	1.2E-07	0.049	0.27	-	0.049	-
NOCF	6.1E-06	1.2	1.6	-	1.2	0.0028

Note: Dashes represent MACCS results that are identically zero.

Table 4-43 shows the areal extent of population restrictions, such as interdiction or condemnation, that may be needed following the accident. Consistent with Section 4.4 of NRC (2022a), examination of the values in Table 4-42 and Table 4-43 suggests that (1) population restrictions would be less widespread than agricultural restrictions, and (2) long-term restrictions, such as condemnation, would be less widespread than temporary restrictions that allow for decontamination, weathering, and radioactive decay to reduce doses to levels allowing habitation.

Table 4-43 Conditional Mean Land Area (mi^2) within 100 Miles Subject to Population Restrictions

Release Category	Frequency (/yr)	Decontamination/Interdiction	Condemnation
ISLOCA	1.3E-07	170	1.6
CIF	1.7E-06	430	3.8
COPEN-RCSINTACT	2.7E-07	3100	11
COPEN-RCSVENT	1.3E-07	5600	44
COPEN-HEADOFF	7.8E-08	4600	36
ECF	5.1E-10	150	0.39
CF-Before-CD	2.1E-06	1200	8.7
ICF-BURN	1.7E-06	200	0.14
LCF	5.5E-08	0.56	-
BMT	1.2E-07	0.00079	-
NOCF	6.1E-06	0.16	-

Note: Dashes represent MACCS results that are identically zero.

The contributions of the different release categories, considering both their frequency and their conditional consequences, are shown in Figure 4-31 and Figure 4-32. The figure of merit selected for more detailed examination is the area within 50 miles (Figure 4-31) and 100 miles

(Figure 4-32) exceeding a Cs-137 deposition level of 555 kBq/m2 (15 Ci/km2), because the initial Cs-137 deposition level drives the potential dose, and therefore the extent of protective actions. Consistent with Section 4.4 of NRC (2022a), the relative contributions of release categories to the conditional mean value for this figure of merit are similar to the relative contributions of release categories to the conditional mean cesium and iodine release fractions shown in Figure 3-1 and Figure 3-2 and are dominated by the CF-Before-CD, CIF, COPEN-RCSINTACT, and COPEN-RCSVENT release categories.

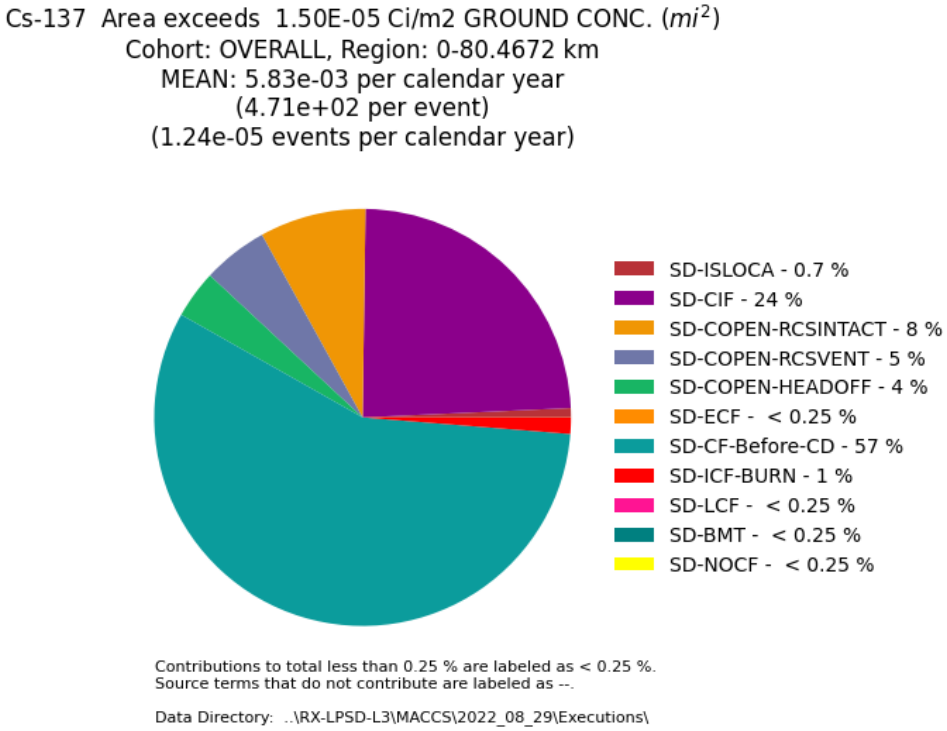


Figure 4-31 Relative Contribution of Release Categories to the Frequency-Weighted Mean Value of Land Exceeding a Deposition of 555 kBq/m^2 (15 Ci/km^2) within 50 Miles

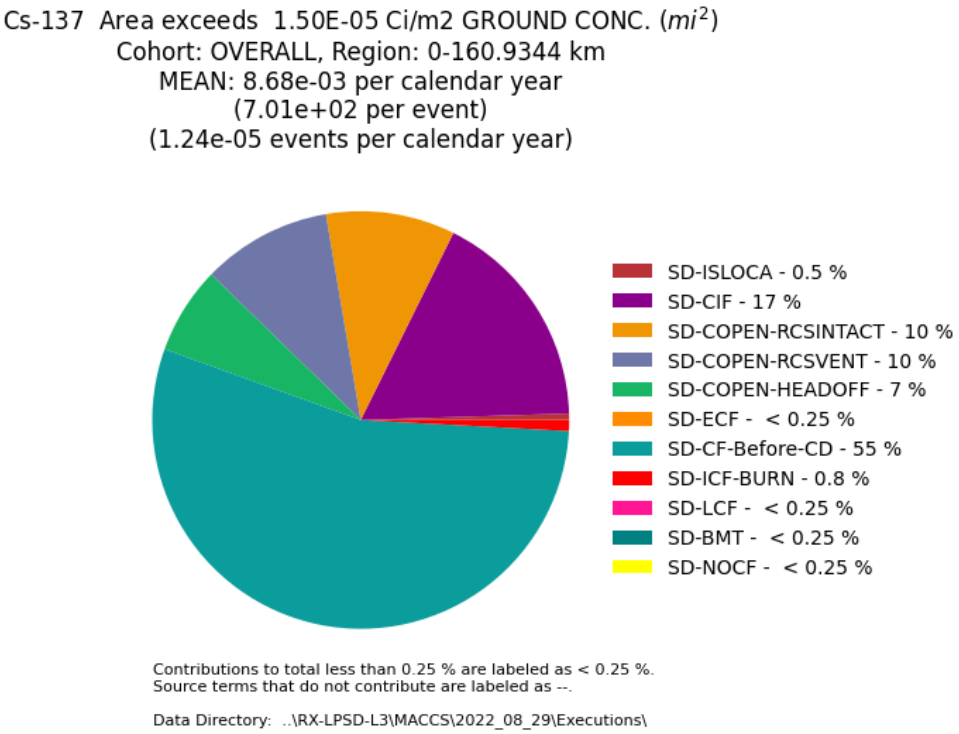


Figure 4-32 Relative Contribution of Release Categories to the Frequency-Weighted Mean Value of Land Exceeding a Deposition of 555 kBq/m^2 (15 Ci/km^2) within 100 Miles

The importance of the release magnitude may be observed in Figure 4-33, showing the relationship between the cesium release magnitude and the conditional mean area subject to two different threshold levels of Cs-137 deposition. Values for the reactor, at-power, internal events and internal flood (IEIF) release categories taken from Table 4-4 of NRC (2022a) are also shown for comparison. Consistent with Section 4.4 of NRC (2022a), inspection of this plot suggests that land contamination increases with the magnitude of the release, and that (for a given release) higher levels of deposition (e.g., 1.5 MBq/m^2 [40 Ci/km^2] versus 555 kBq/m^2 [15 Ci/km^2]) will occur over smaller areas. It may also be noted that the relationship between the release magnitude and the affected area is consistent across both at-power and LPSD release categories, as expected. Finally, it may be noted that the relationship between affected land area and cesium release magnitude is approximately linear over a wide range of cesium release magnitudes. This contrasts with the apparent non-linearity of the conditional latent fatality risks at high release magnitudes observable in Figure 4-17 and Figure 4-24.

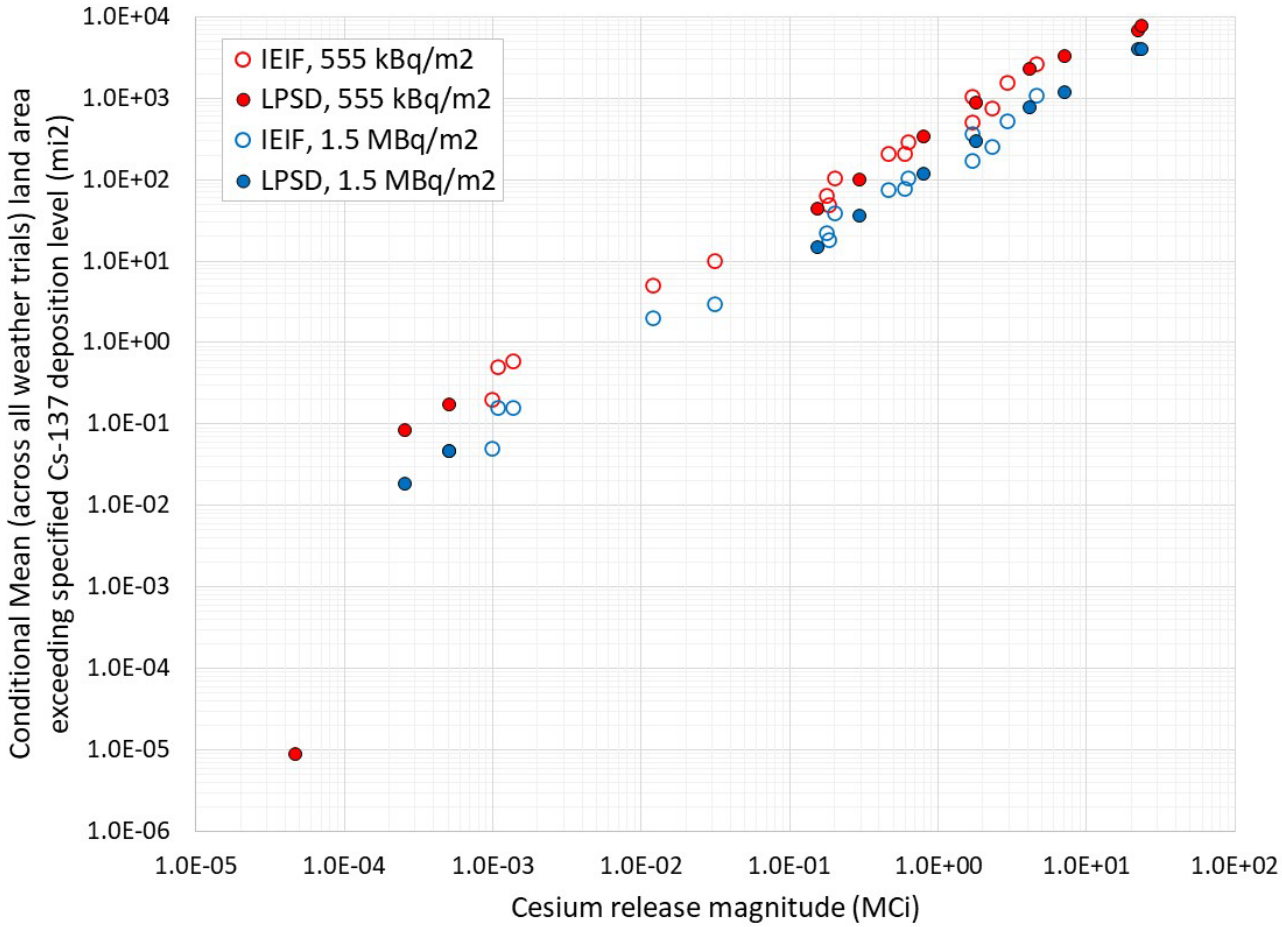


Figure 4-33 Conditional Mean (Across All Weather Trials) Area within 100 Miles Exceeding a Cs-137 Deposition of 1.5 MBq/m^2 (40 Ci/km^2) and 555 kBq/m^2 (15 Ci/km^2) as a Function of Cesium Release Magnitude

The relative contribution of different weather bins and release categories to the conditional mean value of the area exceeding a deposition level of 555 kBq/m^2 (15 Ci/km^2) within 50 and 100 miles was also examined. Consistent with Section 4.4 of NRC (2022a), no pronounced difference in the relative contribution of release categories across different weather bins is particularly noticeable and the corresponding figures are therefore not reproduced here.

The CCDFs of the area within 50 and 100 miles exceeding a deposition level of 555 kBq/m^2 (15 Ci/km^2) are shown in Figure 4-34 and Figure 4-35, respectively. The results shown here are consistent with the results seen in Figure 4-31, Figure 4-32, and Figure 4-33; namely, that the risk of land contamination is largely driven by the CF-Before-CD, CIF, COPEN-RCSINTACT, COPEN-RCSVENT, and COPEN-HEADOFF release categories. This is very similar to the relative contribution of release categories to other aggregate impacts (such as total latent cancer fatality cases or individual latent cancer fatality risk), as well as to the contributions to the conditional mean cesium release fraction and conditional mean iodine release fraction.

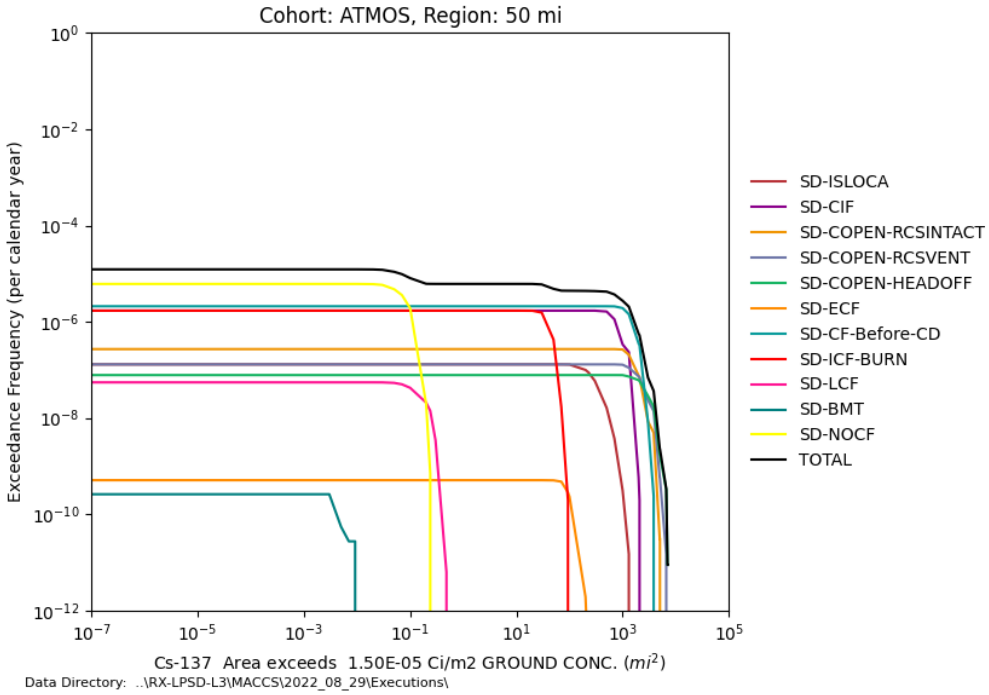


Figure 4-34 Complementary Cumulative Distribution Function, Land Area (mi^2) Exceeding 555 kBq/m^2 (1.50E-05 Ci/m^2) Cs-137 within 50 Miles

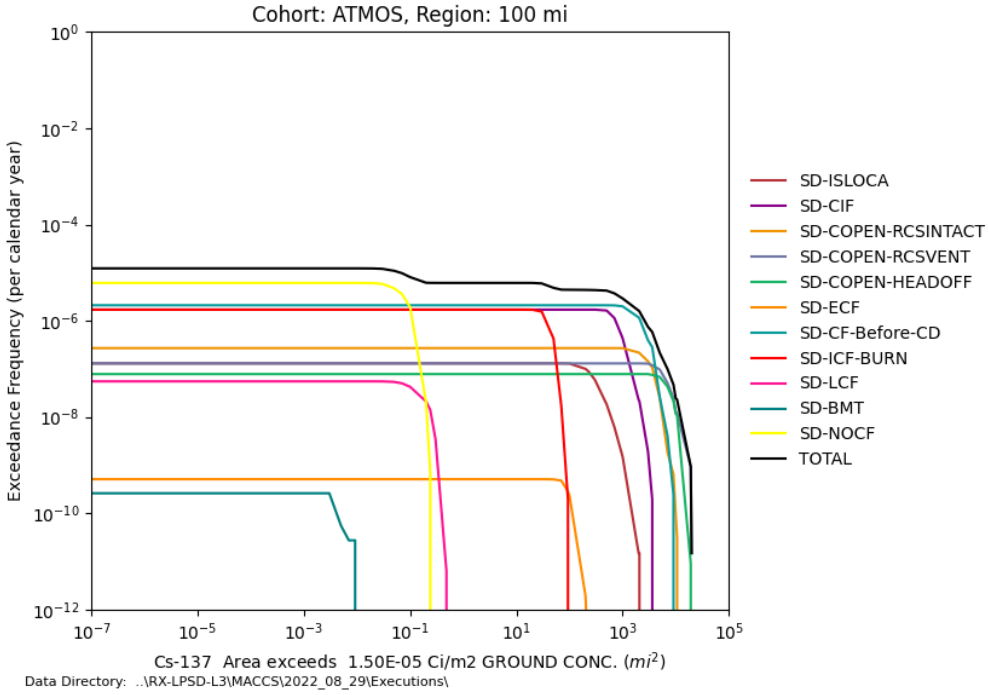


Figure 4-35 Complementary Cumulative Distribution Function, Land Area (mi^2) Exceeding 555 kBq/m^2 (1.50E-05 Ci/m^2) Cs-137 within 100 Miles

4.4.1 Sensitivity Cases

4.4.1.1 Meteorological Sampling

The effect of sampling only a subset of the meteorological data on the land area exceeding 555 kBq/m2 (15 Ci/km2) within 80 and 161 km (50 and 100 mi) is demonstrated in Table 4-44 and Table 4-45. It is evident from inspection of these results that differences resulting from sampling a representative subset of weather trials as opposed to sampling all 8,760 hourly observations are generally less than a few percent.

Table 4-44 Land Area (mi^2) Exceeding 555 kBq/m^2 (15 Ci/km^2) Cs-137, 0–50 Miles (Conditional Mean Value Across All Weather Trials): ME_2

Release Category	Frequency (/yr)	Base Case	ME_2	Fraction of Base Case[2]
ALL[1] (per yr)	**1.2E-05**	**5.8E-03**	**5.8E-03**	**0.995**
ISLOCA	1.3E-07	3.2E+02	3.3E+02	1.028
CIF	1.7E-06	8.3E+02	8.2E+02	0.998
COPEN-RCSINTACT	2.7E-07	1.8E+03	1.8E+03	1.000
COPEN-RCSVENT	1.3E-07	2.3E+03	2.3E+03	0.991
COPEN-HEADOFF	7.8E-08	2.8E+03	2.8E+03	0.993
ECF	5.1E-10	1.0E+02	1.0E+02	1.000
CF-Before-CD	2.1E-06	1.6E+03	1.6E+03	0.994
ICF-BURN	1.7E-06	4.3E+01	4.3E+01	1.007
LCF	5.5E-08	1.7E-01	1.7E-01	1.006
BMT	1.2E-07	8.8E-06	-	-
NOCF	6.1E-06	8.3E-02	8.3E-02	0.998

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of base case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded base case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.

Table 4-45 Land Area (mi^2) Exceeding 555 kBq/m^2 (15 Ci/km^2) Cs-137, 0–100 Miles (Conditional Mean Value Across All Weather Trials): ME_2

Release Category	Frequency (/yr)	Base Case	ME_2	Fraction of Base Case[2]
ALL[1] (per yr)	**1.2E-05**	**8.7E-03**	**8.7E-03**	**1.000**
ISLOCA	1.3E-07	3.3E+02	3.4E+02	1.015
CIF	1.7E-06	8.8E+02	8.8E+02	0.999
COPEN-RCSINTACT	2.7E-07	3.2E+03	3.2E+03	1.006
COPEN-RCSVENT	1.3E-07	6.7E+03	6.7E+03	0.996
COPEN-HEADOFF	7.8E-08	7.5E+03	7.5E+03	0.997
ECF	5.1E-10	1.0E+02	1.0E+02	1.000
CF-Before-CD	2.1E-06	2.3E+03	2.3E+03	1.000
ICF-BURN	1.7E-06	4.3E+01	4.3E+01	1.007
LCF	5.5E-08	1.7E-01	1.7E-01	1.006
BMT	1.2E-07	8.8E-06	-	-
NOCF	6.1E-06	8.3E-02	8.3E-02	0.998

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of base case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded base case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.

4.4.1.2 Accident Termination Time

The effect of terminating the accident release 36 hours after SAMG entry on the area (mi^2) exceeding 555 kBq/m^2 (15 Ci/km^2) Cs-137 within 80 and 161 km (50 and 100 mi) is demonstrated in Table 4-46 and Table 4-47. For sensitivity analysis, only a subset of weather trials was sampled to increase computational efficiency. For this case, the reference case values are therefore the results from ME_2 described in the previous section. These values were selected for the reference case to minimize confounding effects from weather sampling with the effect of accident termination time.

The effect of terminating the release is a reduction in contaminated land. On a frequency-weighted basis, the reduction is only a few percent. Some release categories (such as CF-Before-CD and CIF release categories) are relatively unaffected with a reduction of less than a few percent, whereas other release categories (such as the intermediate containment failure (ICF) release category) are reduced by over 99 percent.

The differential impact of the accident termination time on the relative contribution of release categories to the area (mi^2) exceeding 555 kBq/m^2 (15 Ci/km^2) Cs-137 within 80 and 161 km (50 and 100 mi) is illustrated in Figure 4-36 and Figure 4-37, respectively. The limited frequency-weighted reduction in the extent of land contamination is due to the minimal reduction in the dominant release categories (i.e., CF-Before-CD, CIF, and the COPEN release categories). The relative contribution of release categories to the extent of contaminated land is somewhat similar to the relative contribution of release categories to the cumulative cesium release shown in Figure 4-1.

Table 4-46 Land Area (mi^2) Exceeding 555 kBq/m^2 (15 Ci/km^2) Cs-137, 0–50 Miles (Conditional Mean Value Across All Weather Trials): RE_4

Release Category	Frequency (/yr)	Reference Case (ME_2)	RE_4	Fraction of Reference Case[2]
ALL[1] (per yr)	**1.2E-05**	**5.8E-03**	**5.6E-03**	**0.972**
ISLOCA	1.3E-07	3.3E+02	3.2E+02	0.970
CIF	1.7E-06	8.2E+02	8.1E+02	0.989
COPEN-RCSINTACT	2.7E-07	1.8E+03	1.6E+03	0.910
COPEN-RCSVENT	1.3E-07	2.3E+03	2.2E+03	0.978
COPEN-HEADOFF	7.8E-08	2.8E+03	2.7E+03	0.986
ECF	5.1E-10	1.0E+02	7.3E-01	0.007
CF-Before-CD	2.1E-06	1.6E+03	1.6E+03	0.994
ICF-BURN	1.7E-06	4.3E+01	1.4E-01	0.003
LCF	5.5E-08	1.7E-01	1.3E-01	0.724
BMT	1.2E-07	-	-	-
NOCF	6.1E-06	8.3E-02	7.7E-02	0.929

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of reference case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded reference case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.

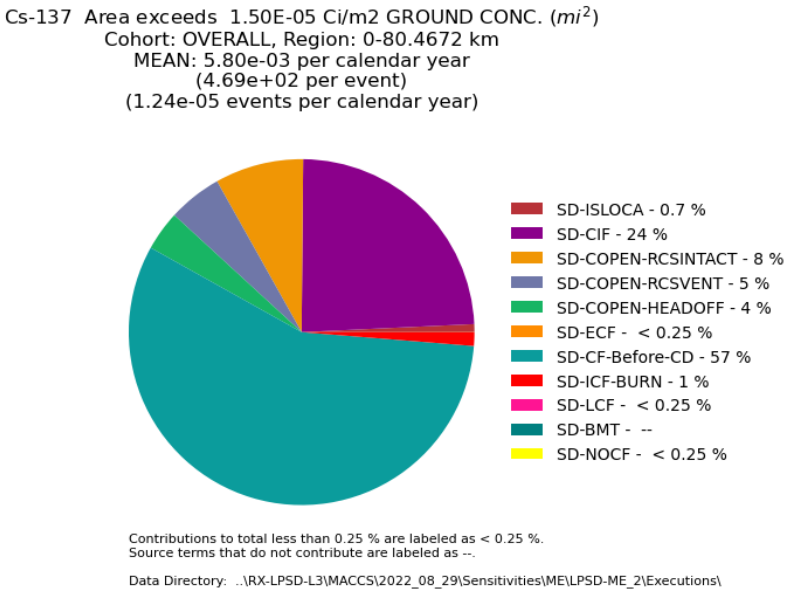
Table 4-47 Land Area (mi^2) Exceeding 555 kBq/m^2 (15 Ci/km^2) Cs-137, 0–100 Miles (Conditional Mean Value Across All Weather Trials): RE_4

Release Category	Frequency (/yr)	Reference Case (ME_2)	RE_4	Fraction of Reference Case[2]
ALL[1] (per yr)	**1.2E-05**	**8.7E-03**	**8.5E-03**	**0.979**
ISLOCA	1.3E-07	3.4E+02	3.3E+02	0.970
CIF	1.7E-06	8.8E+02	8.7E+02	0.989
COPEN-RCSINTACT	2.7E-07	3.2E+03	3.0E+03	0.938
COPEN-RCSVENT	1.3E-07	6.7E+03	6.6E+03	0.991
COPEN-HEADOFF	7.8E-08	7.5E+03	7.5E+03	0.992
ECF	5.1E-10	1.0E+02	7.3E-01	0.007
CF-Before-CD	2.1E-06	2.3E+03	2.3E+03	0.996
ICF-BURN	1.7E-06	4.3E+01	1.4E-01	0.003
LCF	5.5E-08	1.7E-01	1.3E-01	0.724
BMT	1.2E-07	-	-	-
NOCF	6.1E-06	8.3E-02	7.7E-02	0.929

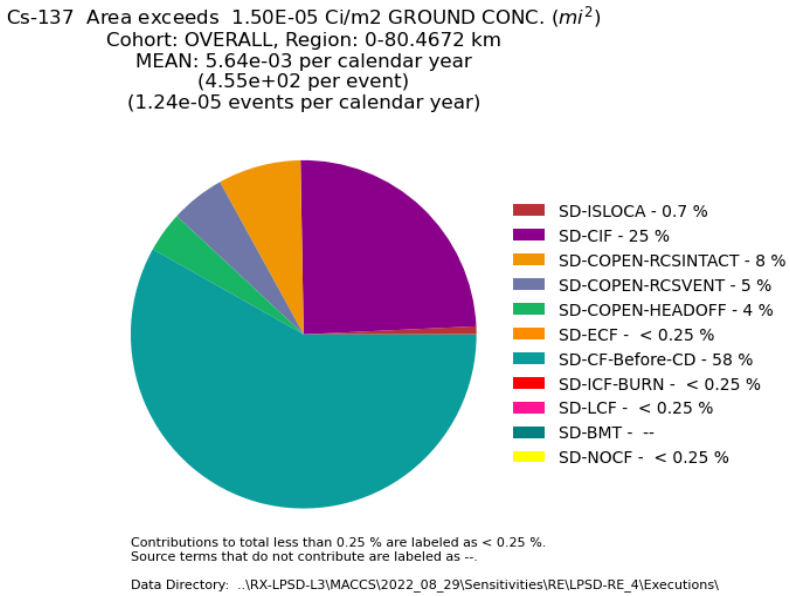
1. Results are a frequency-weighted sum of all release categories.

2. Fraction of reference case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded reference case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.

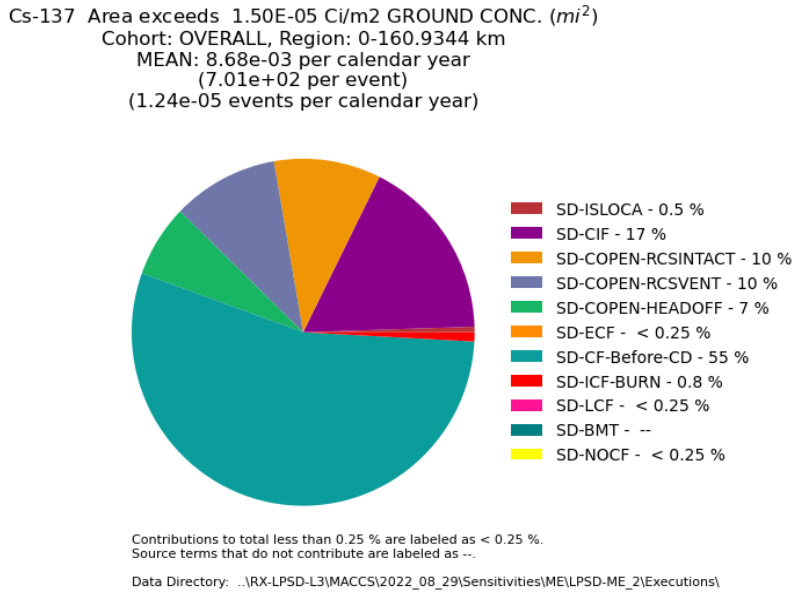


Reference Case (ME_2)

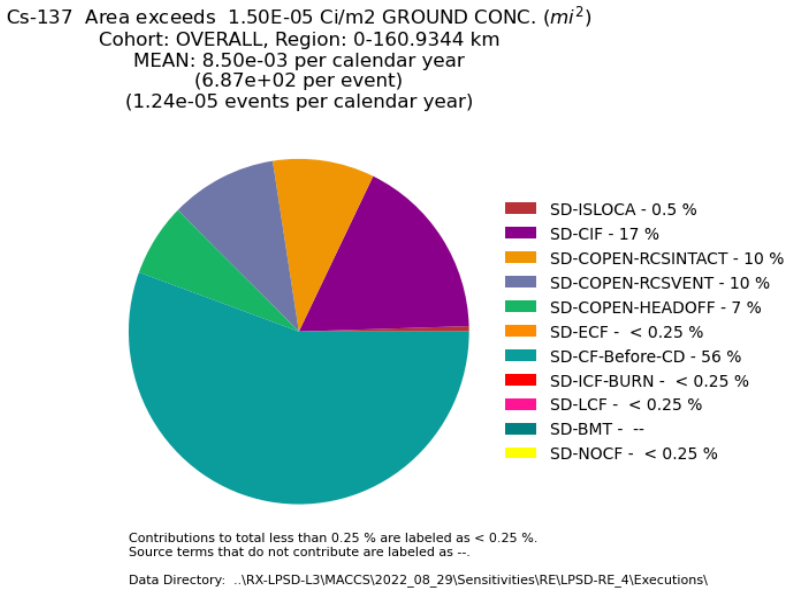


RE_4

Figure 4-36 Relative Contribution of Release Categories to Land Area (mi^2) Exceeding 555 kBq/m^2 (15 Ci/km^2) Cs-137, 0–50 miles: RE_4



Reference Case (ME_2)



RE_4

Figure 4-37 Relative Contribution of Release Categories to Land Area (mi^2) Exceeding 555 kBq/m^2 (15 Ci/km^2) Cs-137, 0–100 Miles: RE_4

4.4.1.3 Low-Dose Cancer Risk Estimation

Inspection of the results for estimated land contamination arising from the use of a model that estimates cancer risk based only on annual individual doses greater than 0.05 Sv (5 rem), or lifetime individual doses greater than 0.1 Sv (10 rem), shows that (as expected) there is no difference between the results of the reference case and the results for sensitivity case HE-2. For this sensitivity analysis, only a subset of weather trials was sampled to increase computational efficiency. For this case, the reference case values are therefore the results from ME_2 described previously. These values were selected for the reference case to minimize confounding effects from weather sampling with the effect of using a dose truncation model. The ratio of the results of the reference and sensitivity case were 1.000 for all release categories and are therefore not reproduced here.

4.5 Affected Population

The following discussion is adapted from Section 4.5 of NRC (2022a) and is modified to discuss the effect of the different release category characteristics associated with the LPSD analysis documented in NRC (2025). The size of the affected population in a MACCS calculation is a function of the period of interest. Using the Type 14 output, MACCS can report the number of people affected by the (1) early-phase actions (which would last on the order of days), (2) intermediate-phase actions (which may last up to a year in MACCS), (3) decontamination efforts (which, in MACCS, may extend for up to a year beyond the intermediate phase, for a total of up to 2 years following the accident), and (4) longer term actions, such as longer term interdiction following decontamination, or condemnation if decontamination is unable to reduce doses to habitability criteria. The specific outputs are as follows:

- EVACUEES NOT AFFECTED BY PLUME[11]: the number of evacuees whose property is not contaminated and can return during or immediately after the emergency phase.
- EVACUEES AFFECTED BY PLUME: the number of evacuees whose property is contaminated and may not be able to return during or immediately after the emergency phase.
- NORMAL EMERGENCY PHASE RELOCATION: the number of relocatees who are affected by normal relocation during the emergency phase.
- HOTSPOT EMERGENCY PHASE RELOCATION: the number of relocatees who are affected by hotspot relocation during the emergency phase.
- INTERMEDIATE-PHASE RELOCATION: the number of relocatees during the intermediate phase
- LEVEL 1 DECONTAMINATION RELOCATION: the number of people whose property requires the first level of decontamination during the long-term phase.

[11] Shortly before completion of this document, a potential error in the Type 14 output for the number of evacuees not affected by the plume for cohorts modeled with a keyhole evacuation was identified. That detailed output metric value is therefore not tabulated in this report.

- LEVEL 2 DECONTAMINATION RELOCATION: the number of people whose property requires the second level of decontamination during the long-term phase.

- LEVEL 3 DECONTAMINATION RELOCATION: the number of people whose property requires the third level of decontamination during the long-term phase but can return immediately after the decontamination is completed.

- DECONTAMINATION+INTERDICTION RELOCATION: the number of people whose property requires the highest level of decontamination (depending on the number of levels specified in the input) plus additional interdiction following the decontamination.

- CONDEMNATION RELOCATION: the number of people whose property is condemned.

The conditional mean size of the population within 50 and 100 miles subject to early-phase protective actions is shown by release category in Table 4-48 and Table 4-49, respectively. The conditional mean size of the population subject to intermediate- and recovery-phase protective actions is shown by release category for these same distances in Table 4-50 and Table 4-51, respectively.

Table 4-48 Conditional Mean (Across All Weather Trials) Size of Population within 50 Miles Subject to Early-Phase Protective Actions

Release Category	Freq (/yr)	Evacuees Affected by Plume	Hotspot Relocation	Normal Relocation
ISLOCA	1.3E-07	69,000	1.3	900
CIF	1.7E-06	48,000	0.53	13
COPEN-RCSINTACT	2.7E-07	69,000	5,100	110,000
COPEN-RCSVENT	1.3E-07	70,000	42,000	130,000
COPEN-HEADOFF	7.8E-08	59,000	14,000	95,000
ECF	5.1E-10	69,000	0.72	110
CF-Before-CD	2.1E-06	49,000	2.4	2,600
ICF-BURN	1.7E-06	68,000	1.3	970
LCF	5.5E-08	16,000	-	-
BMT	1.2E-07	13,000	-	-
NOCF	6.1E-06	16,000	-	-

Note: Dashes represent MACCS results that are identically zero.

Table 4-49 Conditional Mean (Across All Weather Trials) Size of Population within 100 Miles Subject to Early-Phase Protective Actions

Release Category	Freq (/yr)	Evacuees Affected by Plume	Hotspot Relocation	Normal Relocation
ISLOCA	1.3E-07	69,000	1.3	900
CIF	1.7E-06	48,000	0.53	13
COPEN-RCSINTACT	2.7E-07	69,000	5,100	120,000
COPEN-RCSVENT	1.3E-07	70,000	44,000	310,000
COPEN-HEADOFF	7.8E-08	59,000	14,000	140,000
ECF	5.1E-10	69,000	0.72	110
CF-Before-CD	2.1E-06	49,000	2.4	2,600
ICF-BURN	1.7E-06	68,000	1.3	980
LCF	5.5E-08	16,000	-	-
BMT	1.2E-07	13,000	-	-
NOCF	6.1E-06	16,000	-	-

Note: Dashes represent MACCS results that are identically zero.

Table 4-50 Conditional Mean (Across All Weather Trials) Size of Population Within 50 Miles Subject to Intermediate-and Recovery-Phase Protective Actions

Release Category	Freq (/yr)	Intermediate Phase Relocation	Level 1 Decon	Level 2 Decon	Level 3 Decon	Decontamination + Interdiction	Condemnation
ISLOCA	1.3E-07	8,900	16,000	790	540	76	6.2
CIF	1.7E-06	22,000	43,000	2,100	1,400	170	14
COPEN-RCSINTACT	2.7E-07	180,000	100,000	17,000	14,000	2,600	180
COPEN-RCSVENT	1.3E-07	260,000	93,000	31,000	53,000	24,000	2,200
COPEN-HEADOFF	7.8E-08	200,000	130,000	38,000	52,000	18,000	1,500
ECF	5.1E-10	8,300	960	34	21	2.7	-
CF-Before-CD	2.1E-06	73,000	99,000	11,000	6,200	1,200	68
ICF-BURN	1.7E-06	17,000	180	7.6	3.4	0.043	-
LCF	5.5E-08	0.5	0.19	-	-	-	-
BMT	1.2E-07	-	-	-	-	-	-
NOCF	6.1E-06	-	0.0029	-	-	-	-

Note: Dashes represent MACCS results that are identically zero.

Table 4-51 Conditional Mean (Across All Weather Trials) Size of Population Within 100 Miles Subject to Intermediate-and Recovery-Phase Protective Actions

Release Category	Freq (/yr)	Intermediate Phase Relocation	Level 1 Decon	Level 2 Decon	Level 3 Decon	Decontamination + Interdiction	Condemnation
ISLOCA	1.3E-07	8,900	16,000	790	540	76	6.2
CIF	1.7E-06	22,000	44,000	2,100	1,400	170	14
COPEN-RCSINTACT	2.7E-07	350,000	190,000	19,000	15,000	2,600	180
COPEN-RCSVENT	1.3E-07	720,000	470,000	77,000	78,000	25,000	2,200
COPEN-HEADOFF	7.8E-08	470,000	530,000	69,000	66,000	19,000	1,500
ECF	5.1E-10	8,300	960	34	21	2.7	-
CF-Before-CD	2.1E-06	80,000	130,000	11,000	6,200	1,200	68
ICF-BURN	1.7E-06	18,000	180	7.6	3.4	0.043	-
LCF	5.5E-08	0.5	0.19	-	-	-	-
BMT	1.2E-07	-	-	-	-	-	-
NOCF	6.1E-06	-	0.0029	-	-	-	-

Note: Dashes represent MACCS results that are identically zero.

Consistent with Section 4.5 of NRC (2022a), a few observations may be drawn from these tables:

- Early-phase protective actions are largely confined to the area within 50 miles of the site. Although some of the population beyond 50 miles may be projected to receive doses greater than 1 rem in 4 days, only for the COPEN-RCSVENT release category are any of the population (on average) beyond 50 miles projected to exceed the upper (5 rem) PAG limit associated with MACCS hotspot relocation.

- Most of the affected population in the recovery phase is due to those requiring a relatively limited level of decontamination (no more than a decontamination factor [DF] of 3). The size of the population requiring more extensive protective actions (Level 2 and Level 3 decontamination with DF greater than 3, decontamination followed by interdiction, or condemnation) is, on average, much smaller.

However, unlike the results obtained in the at-power scenarios, the size of the affected population for LPSD scenarios may either increase or decrease as a function of the time since the accident. The size of the population subject to either intermediate-phase relocation (i.e., projected to receive a dose greater than 2 rem in the year of the accident) or decontamination or condemnation (i.e., projected to receive a dose greater than 500 mrem in the year after the accident) was generally smaller than the early-phase evacuation and relocation population for the at-power release categories. The only exceptions were the low frequency SGTR-O and ECF release categories, which had the largest at-power cesium release fractions. In contrast, the larger cesium release magnitudes associated with several of the LPSD release categories resulted in late-phase affected populations larger than the early-phase affected population size. The relationship between the size of the early- and late-phase affected populations and the cesium release magnitude is shown in Figure 4-38. The total early-phase affected population in this plot is the sum of the evacuees affected by the plume and the size of the population subject to either hotspot or normal early-phase relocation. The total late-phase affected population in the plot is the larger of either the population relocated during the intermediate phase or the sum of the populations subject to decontamination, decontamination plus interdiction, and condemnation. The comparable values from the reactor, at-power, internal events and floods (IEIF) release categories, based on data from Table 4.5-2 and 4.5-4 of NRC (2022a), are shown for comparison. It may be seen from this plot that for release magnitudes below a few megacuries of cesium, the early-phase affected population size is generally larger than the late-phase affected population size. Above this release magnitude, the late-phase population is generally larger than the early-phase affected population.

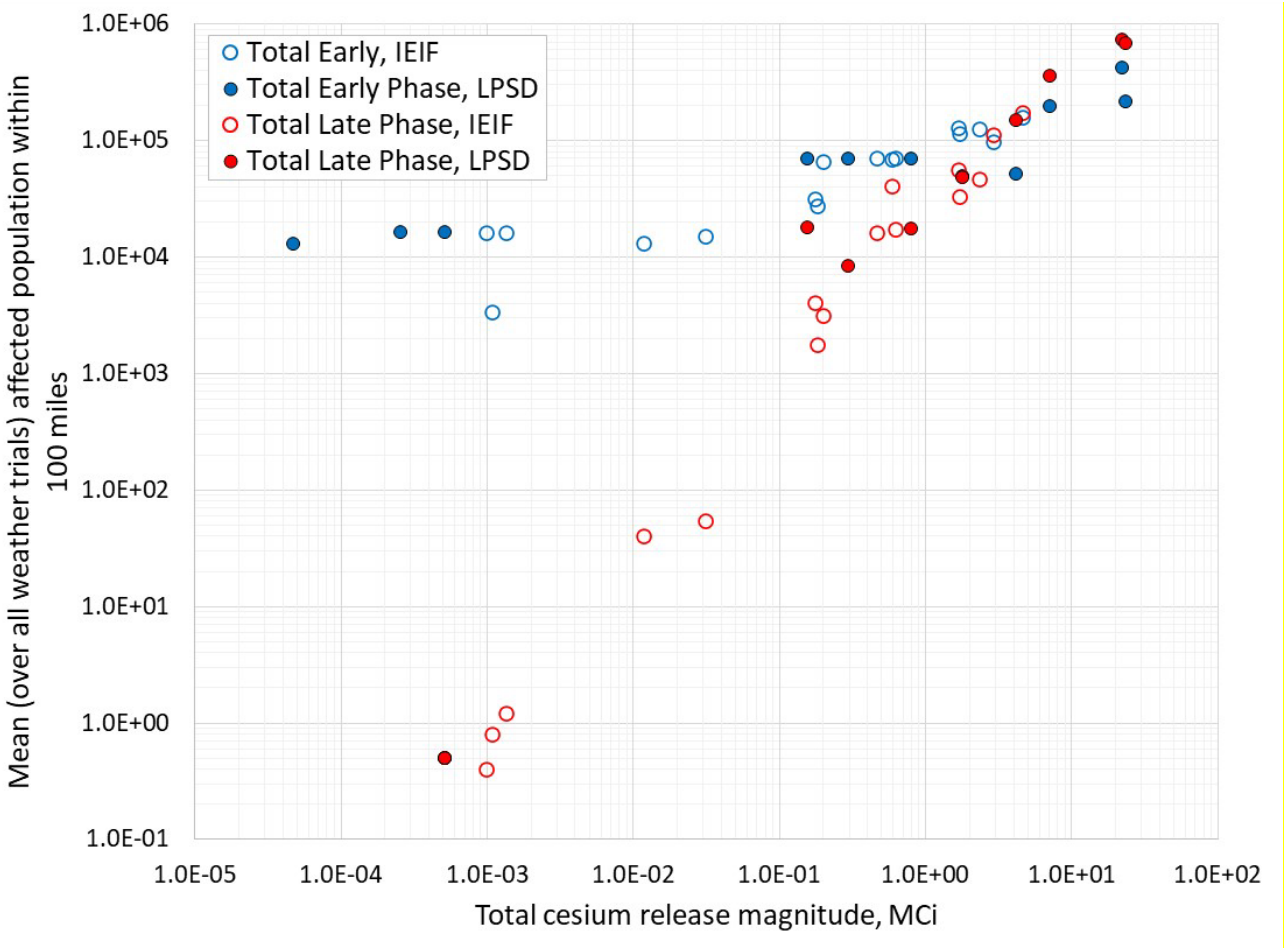


Figure 4-38 Conditional Mean (Across All Weather Trials) Size of Population Subject to Early- and Late-Phase Relocation as a Function of Cesium Release Magnitude

The conditional mean size of population within 50 and 100 miles subject to intermediate-phase relocation as a function of cesium release is shown in Figure 4-39. Two observations may be drawn from this plot:

- The conditional mean size of the population subject to intermediate-phase relocation is closely related to the magnitude of the cesium release fraction across a wide range of release magnitudes, consistent with the relationship previously shown in Figure 4-38.

- The two plots are very similar, suggesting that intermediate-phase relocation is unlikely (on average) to extend beyond 50 miles. There is a difference between the 50- and 100-mile results for the largest releases, suggesting that releases larger than several megacuries may result in a higher likelihood of intermediate-phase relocation beyond 50 miles. However, most of the affected population is concentrated within 50 miles for releases less than several megacuries.

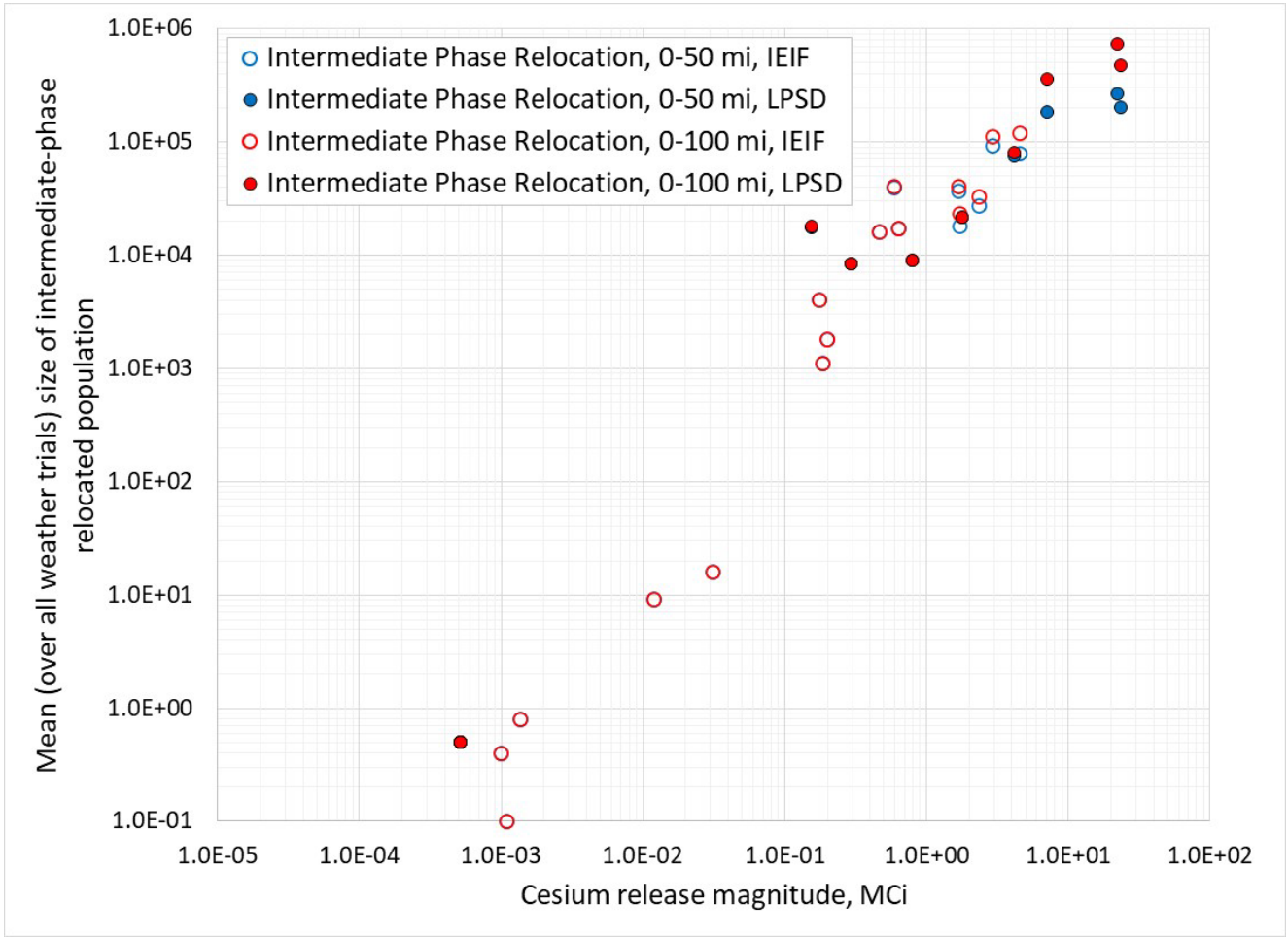


Figure 4-39 Conditional Mean (Across All Weather Trials) Size of Population Subject to Intermediate-Phase Relocation within 50 and 100 Miles as a Function of Cesium Release Magnitude

The contributions of individual release categories to the conditional mean value of population subject to early-, intermediate-, and recovery-phase protective actions are shown in Figure 4-40 through Figure 4-43. Figure 4-40 shows the contributions of individual release categories to the conditional mean value of population subject to early-phase protective actions within 100 miles. The figure of merit used to generate this curve is the sum of the evacuees affected by the plume and the size of the population subject to either hotspot or normal early-phase relocation. Figure 4-41 shows the contribution of release categories to the conditional mean value of the combined intermediate- and recovery-phase affected population within 100 miles. The total late-phase affected population in the plot is the larger of either the population relocated during the intermediate phase or the sum of the populations subject to decontamination, decontamination plus interdiction, and condemnation in the recovery phase. Figure 4-42 and Figure 4-43 show the contribution of release categories to the conditional mean value of the intermediate-phase affected population within 50 and 100 miles, respectively. A clear distinction between the drivers of the population affected by early-phase actions versus intermediate-phase actions is evident. The contribution of release categories to the conditional mean size of the early-phase affected population (shown in Figure 4-40) has a sizable contribution from the relatively higher frequency, lower consequence NOCF release category, because that case is modeled with a full evacuation of the 10-mile EPZ, the restricted access industrial facility, and a 5-mile shadow evacuation outside the EPZ. In contrast, the relative contribution of release categories to the size of the populations subject to late-phase (Figure 4-41) or intermediate-phase relocation (shown in Figure 4-42 and Figure 4-43) are much more similar to the contributors to the conditional mean cesium release fraction shown in Figure 3-3, and are dominated by the CF-Before-CD, CIF, COPEN-RCSINTACT, COPEN-RCSVENT, and COPEN-HEADOFF release categories.

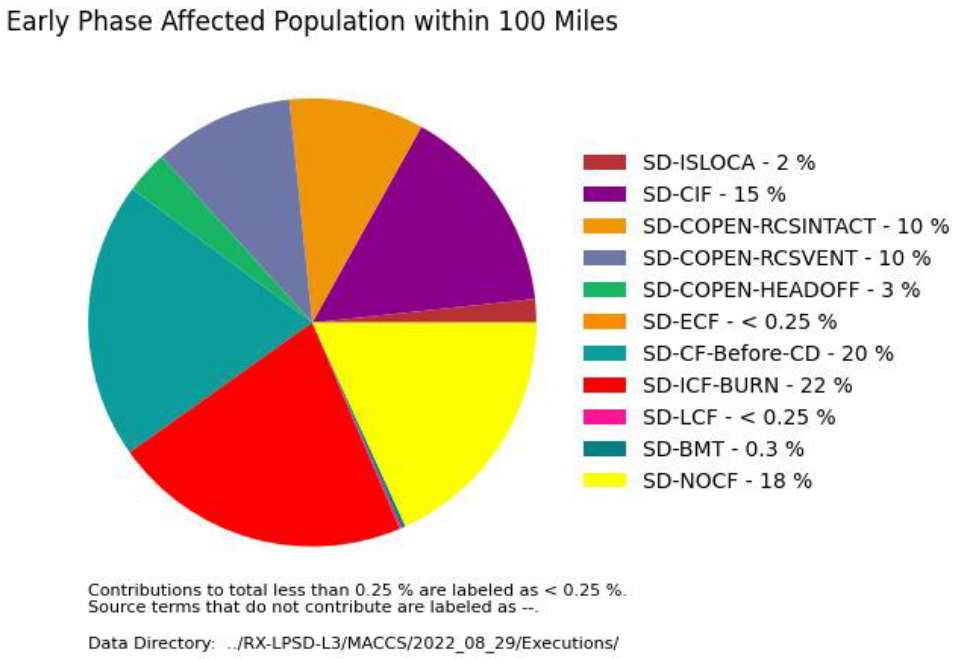


Figure 4-40 Contribution of Release Categories to Conditional Mean (Across All Weather Trials) Early-Phase Affected Population Size within 100 Miles

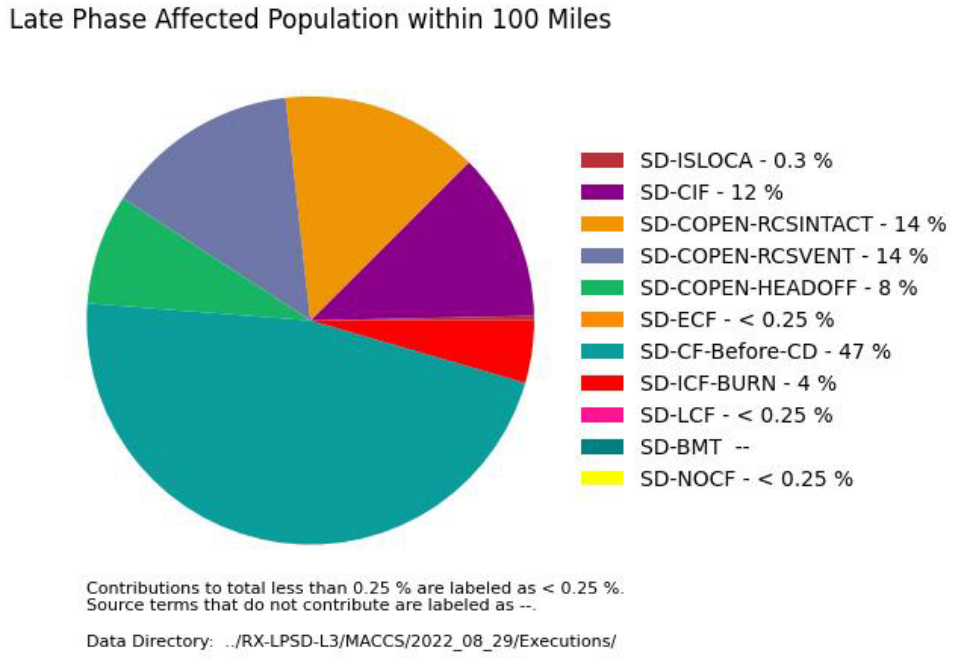


Figure 4-41 Contribution of Release Categories to Conditional Mean (Across All Weather Trials) Combined Intermediate- and Recovery-Phase Affected Population Size within 100 Miles

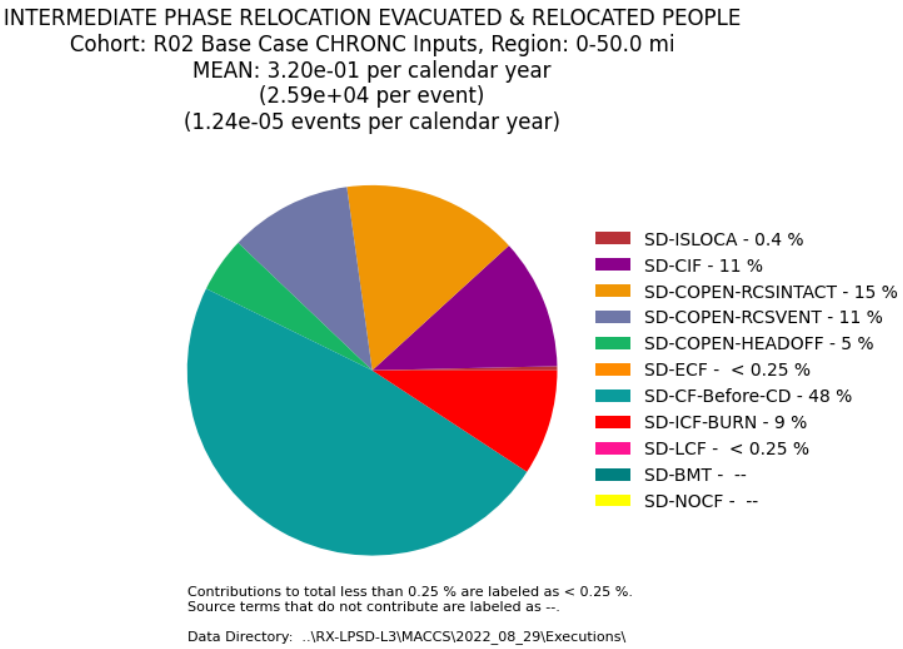


Figure 4-42 Contribution of Release Categories to Conditional Mean (Across All Weather Trials) Intermediate-Phase-Affected Population Size within 50 Miles

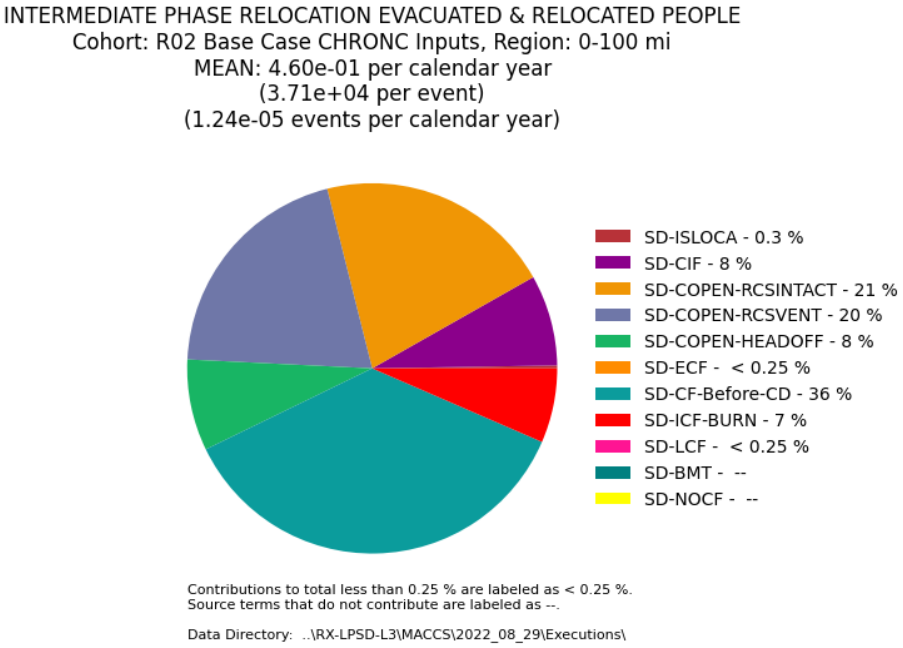


Figure 4-43 Contribution of Release Categories to Conditional Mean (Across All Weather Trials) Intermediate-Phase-Affected Population Size within 100 Miles

The relative contribution of different weather bins and release categories to the conditional mean value of the population within 100 miles subject to intermediate-phase relocation was also examined. Consistent with Section 4.5 of NRC (2022a), no pronounced difference in the relative contribution of release categories across different weather bins is particularly noticeable and the corresponding figures are therefore not reproduced here.

The CCDF of the population within 50 and 100 miles subject to intermediate-phase relocation is shown in Figure 4-44 and Figure 4-45, respectively. The results shown here are consistent with the results seen in Figure 4-42 and Figure 4-43; namely, that the risk of intermediate-phase population relocation is largely driven by CF-Before-CD, CIF, COPEN-RCSINTACT, COPEN-RCSVENT, and COPEN-HEADOFF release categories. The COPEN-RCSVENT release category appears more likely to result in larger affected population sizes, as seen by the fact that the COPEN-RCSVENT curve crosses over the other release category curves at low frequencies. This is very similar to the relative contribution of release categories to other aggregate impacts (such as total latent cancer fatality cases or individual latent cancer fatality risk), as well as to the contributions to the conditional mean cesium release fraction and conditional mean iodine release fraction.

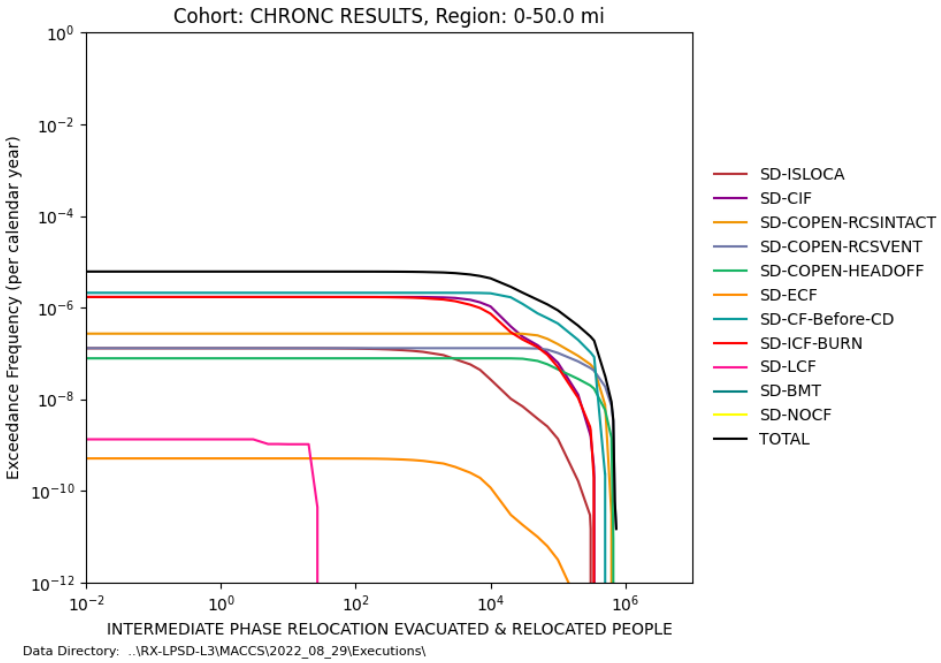


Figure 4-44 Complementary Cumulative Distribution Function of Population Subject to Intermediate-Phase Relocation within 50 Miles

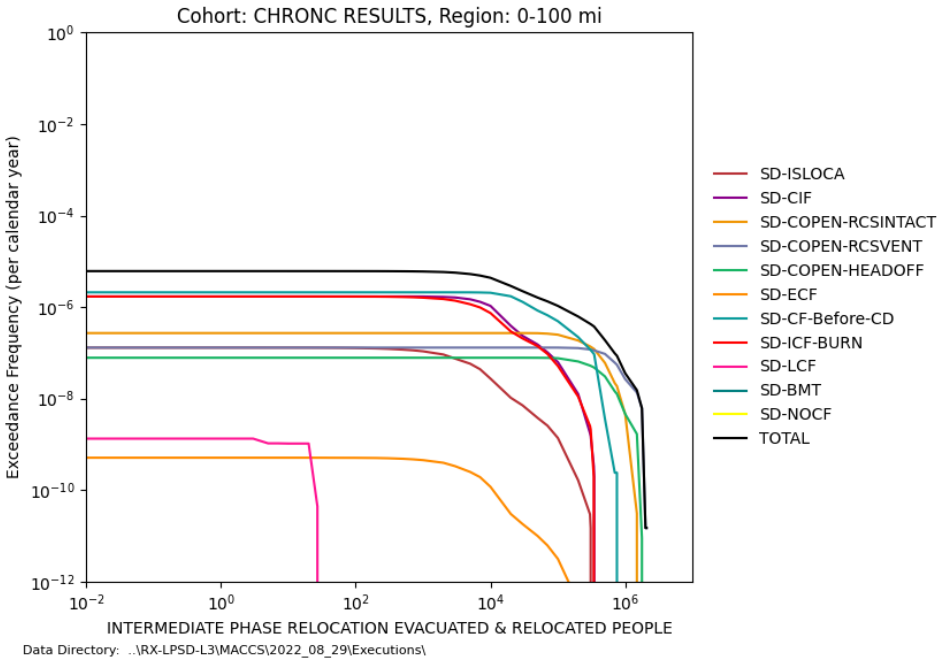


Figure 4-45 Complementary Cumulative Distribution Function of Population Subject to Intermediate-Phase Relocation within 100 Miles

4.5.1 Sensitivity Cases

4.5.1.1 Meteorological Sampling

The effect of sampling only a subset of the meteorological data on the population relocated during the intermediate phase within 80 and 161 km (50 and 100 mi) is demonstrated in Table 4-52 and Table 4-53, respectively. It is evident from inspection of these results that differences resulting from sampling a representative subset of weather trials as opposed to sampling all 8,760 hourly observations are generally less than a few percent. The release category which showed a larger relative difference (LCF) was characterized by very low base case results (with mean values less than a single person). For these changes, a slight absolute difference in the results can be expected to result in a larger relative difference, due to the low values in the denominator of the ratio.

Table 4-52 Summary of Population Relocated during Intermediate Phase, 0–50 Miles (Persons) (Mean Value Across All Weather Trials): ME_2

Release Category	Frequency (/yr)	Base Case	ME_2	Fraction of Base Case[2]
ALL[1] (per yr)	**1.2E-05**	**3.2E-01**	**3.1E-01**	**0.980**
ISLOCA	1.3E-07	8.9E+03	9.6E+03	1.077
CIF	1.7E-06	2.2E+04	2.1E+04	0.972
COPEN-RCSINTACT	2.7E-07	1.8E+05	1.8E+05	0.995
COPEN-RCSVENT	1.3E-07	2.6E+05	2.6E+05	0.996
COPEN-HEADOFF	7.8E-08	2.0E+05	1.9E+05	0.970
ECF	5.1E-10	8.3E+03	8.8E+03	1.058
CF-Before-CD	2.1E-06	7.3E+04	7.0E+04	0.948
ICF-BURN	1.7E-06	1.7E+04	1.9E+04	1.115
LCF	5.5E-08	5.0E-01	3.8E-01	0.765
BMT	1.2E-07	-	-	-
NOCF	6.1E-06	-	-	-

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of base case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded base case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.

Table 4-53 Summary of Population Relocated during Intermediate Phase, 0–100 Miles (Persons) (Mean Value Across All Weather Trials): ME_2

Release Category	Frequency (/yr)	Base Case	ME_2	Fraction of Base Case[2]
ALL[1] (per yr)	**1.2E-05**	**4.6E-01**	**4.6E-01**	**0.989**
ISLOCA	1.3E-07	8.9E+03	9.6E+03	1.073
CIF	1.7E-06	2.2E+04	2.1E+04	0.977
COPEN-RCSINTACT	2.7E-07	3.5E+05	3.5E+05	0.989
COPEN-RCSVENT	1.3E-07	7.2E+05	7.2E+05	1.007
COPEN-HEADOFF	7.8E-08	4.7E+05	4.7E+05	1.009
ECF	5.1E-10	8.3E+03	8.8E+03	1.059
CF-Before-CD	2.1E-06	8.0E+04	7.6E+04	0.956
ICF-BURN	1.7E-06	1.8E+04	1.9E+04	1.102
LCF	5.5E-08	5.0E-01	3.8E-01	0.765
BMT	1.2E-07	-	-	-
NOCF	6.1E-06	-	-	-

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of base case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded base case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.

4.5.1.2 Accident Termination Time

The effect of terminating the accident release 36 hours after SAMG entry on the population relocated during the intermediate phase within 80 and 161 km (50 and 100 mi) is demonstrated in Table 4-54 and Table 4-55, respectively. For sensitivity analysis, only a subset of weather trials was sampled to increase computational efficiency. For this case, the reference case values are therefore the results from ME_2 described in the previous section. These values were selected for the reference case to minimize confounding effects from weather sampling with the effect of accident termination time.

The effect of terminating the release is a reduction in the population relocated during the intermediate phase. On a frequency-weighted basis, the reduction is approximately 20–25 percent. Some release categories (such as ISLOCA or CIF) are relatively unaffected, with a reduction on the order of a few percent, whereas other release categories (such as ECF) are reduced by over 99 percent. Some release categories (such as ICF-BURN and LCF) are completely eliminated, because the reduced releases were not projected to require an intermediate phase. The COPEN-RCSVENT and COPEN-RCSINTACT release categories are noticeably affected, with reductions on the order of 30–70 percent.

The differential impact of the accident termination time on the relative contribution of release categories to the population relocated during the intermediate phase within 80 and 161 km (50 and 100 mi) is illustrated in Figure 4-46 and Figure 4-47, respectively. The frequency-weighted reduction in the population relocated during the intermediate phase is a combination of the much lower conditional consequences for the ICF release category with a noticeable (great than

30 percent) reduction in the conditional consequences for the COPEN-RCSVENT and COPEN-RCSINTACT release categories. The relative contribution of release categories to the population relocated during the intermediate phase is similar to the relative contribution of release categories to the cumulative cesium release shown in Figure 4-1, with the CIF and CF-Before-CD release categories increasing in relative importance and the ICF release category comprising a much smaller contributor.

Table 4-54 Summary of Population Relocated during Intermediate Phase, 0–50 Miles (Persons) (Mean Value Across All Weather Trials): RE_4

Release Category	Frequency (/yr)	Reference Case (ME_2)	RE_4	Fraction of Reference Case[2]
ALL[1] (per yr)	**1.2E-05**	**3.1E-01**	**2.5E-01**	**0.784**
ISLOCA	1.3E-07	9.6E+03	9.4E+03	0.981
CIF	1.7E-06	2.1E+04	2.1E+04	0.995
COPEN-RCSINTACT	2.7E-07	1.8E+05	9.2E+04	0.504
COPEN-RCSVENT	1.3E-07	2.6E+05	1.9E+05	0.711
COPEN-HEADOFF	7.8E-08	1.9E+05	1.9E+05	0.995
ECF	5.1E-10	8.8E+03	6.8E-02	0.000
CF-Before-CD	2.1E-06	7.0E+04	6.9E+04	0.999
ICF-BURN	1.7E-06	1.9E+04	-	-
LCF	5.5E-08	3.8E-01	-	-
BMT	1.2E-07	-	-	-
NOCF	6.1E-06	-	-	-

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of reference case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded reference case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.

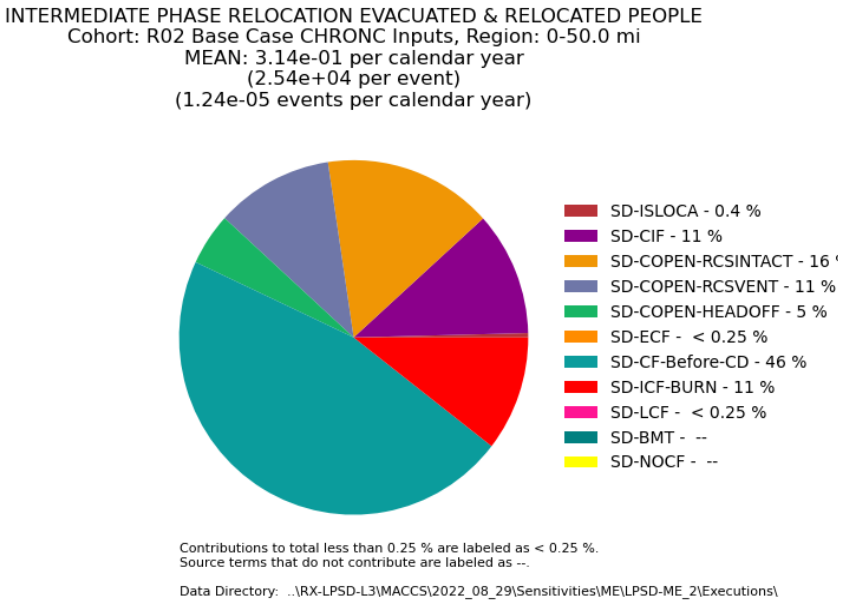
Table 4-55 Summary of Population Relocated during Intermediate Phase, 0–100 Miles (Persons) (Mean Value Across All Weather Trials): RE_4

Release Category	Frequency (/yr)	Reference Case (ME_2)	RE_4	Fraction of Reference Case[2]
ALL[1] (per yr)	**1.2E-05**	**4.6E-01**	**3.4E-01**	**0.736**
ISLOCA	1.3E-07	9.6E+03	9.4E+03	0.981
CIF	1.7E-06	2.1E+04	2.1E+04	0.990
COPEN-RCSINTACT	2.7E-07	3.5E+05	1.3E+05	0.361
COPEN-RCSVENT	1.3E-07	7.2E+05	5.3E+05	0.725
COPEN-HEADOFF	7.8E-08	4.7E+05	4.7E+05	0.994
ECF	5.1E-10	8.8E+03	6.8E-02	0.000
CF-Before-CD	2.1E-06	7.6E+04	7.6E+04	0.999
ICF-BURN	1.7E-06	1.9E+04	-	-
LCF	5.5E-08	3.8E-01	-	-
BMT	1.2E-07	-	-	-
NOCF	6.1E-06	-	-	-

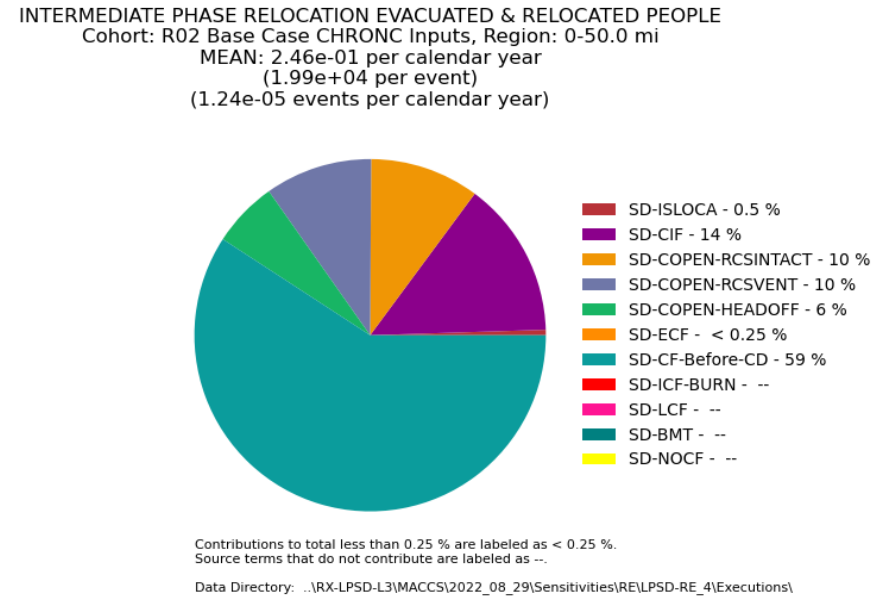
1. Results are a frequency-weighted sum of all release categories.

2. Fraction of reference case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded reference case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Note: Dashes represent MACCS results that are identically zero.

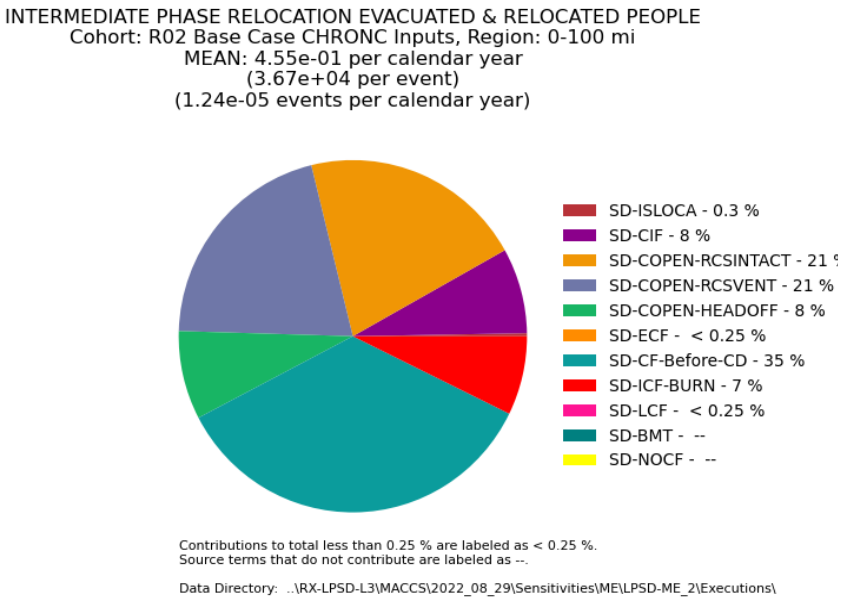


Reference Case (ME_2)

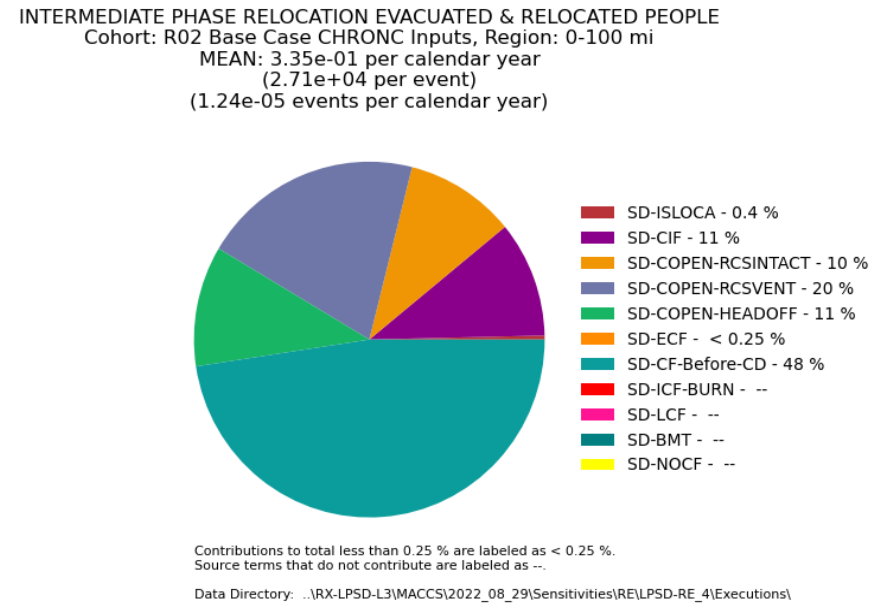


RE_4

Figure 4-46 Relative Contribution of Release Categories to Population Relocated during Intermediate Phase, 0–50 Miles (Persons): RE_4



Reference Case (ME_2)



RE_4

Figure 4-47 Relative Contribution of Release Categories to Population Relocated during Intermediate Phase, 0–100 Miles (Persons): RE_4

4.5.1.3 Low-Dose Cancer Risk Estimation

Inspection of the results for the estimated size of populations subject to intermediate phase relocation results arising from the use of a model that estimates cancer risk based only on annual individual doses greater than 0.05 Sv (5 rem), or lifetime individual doses greater than 0.1 Sv (10 rem), shows that (as expected) there is no significant difference between the results of the reference case and the results for sensitivity case HE-2. For this sensitivity analysis, only a subset of weather trials was sampled to increase computational efficiency. For this case, the reference case values are therefore the results from ME_2 described previously. These values were selected for the reference case to minimize confounding effects from weather sampling with the effect of using a dose truncation model. The ratio of the results of the reference and sensitivity case were 1.000 for all release categories and are therefore not reproduced here.[12]

4.6 Economic Costs

The following discussion is adapted from Section 4.6 of NRC (2022a) and is modified to discuss the effect of the different release category characteristics associated with the LPSD analysis documented in NRC (2025). Economic costs arise from the protective actions assumed to be taken to reduce exposures arising from the accident. They include the daily costs for evacuees and relocatees, as well as the cost associated with the depreciation and loss of use of interdicted property, the cost of decontamination or condemnation, and the costs arising from the implementation of agricultural countermeasures. The economic costs are characterized in terms of the total cost of protective actions within 50 and 100 miles of the site. The MACCS Type 10 output is used to tabulate economic costs.

The conditional mean costs associated with agricultural restrictions within 50 and 100 miles are shown in Table 4-56 and Table 4-57, respectively. The conditional mean costs associated with population restrictions within 50 and 100 miles are shown in Table 4-58 and Table 4-59, respectively.

[12] Although the ratio of HE_2 intermediate and recovery phase relocated populations to ME_2 intermediate and recovery phase relocated populations was 1.000 for all release categories, slight (≤10% for all but the smallest values) differences were observed for early phase affected populations (evacuees affected and unaffected by the plume as well as hot-spot and normal relocated populations). The reason for these reductions is unclear.

Table 4-56 Conditional Mean (Over All Weather Trials) Economic Costs within 50 Miles for Agricultural Restrictions (2015$)

Release Category	Freq (/yr)	Crop Disposal	Milk Disposal	Farmland Decon	Farmland Interdiction	Farmland Condemn.	Total Farm-Dependent
ISLOCA	1.3E-07	1.9E+08	4.3E+06	-	1.7E+08	1.4E+08	5.0E+08
CIF	1.7E-06	2.6E+08	4.0E+06	-	2.3E+08	3.6E+08	8.5E+08
COPEN-RCSINTACT	2.7E-07	3.8E+08	5.9E+06	-	2.7E+08	8.8E+08	1.5E+09
COPEN-RCSVENT	1.3E-07	3.2E+08	5.1E+06	-	1.5E+08	1.3E+09	1.8E+09
COPEN-HEADOFF	7.8E-08	3.4E+08	5.2E+06	-	1.7E+08	1.5E+09	2.0E+09
ECF	5.1E-10	1.9E+08	4.1E+06	-	1.7E+08	4.6E+07	4.0E+08
CF-Before-CD	2.1E-06	2.8E+08	4.2E+06	-	2.0E+08	7.5E+08	1.2E+09
ICF-BURN	1.7E-06	1.5E+08	4.0E+06	-	1.2E+08	1.9E+07	2.9E+08
LCF	5.5E-08	4.7E+05	3.6E+04	-	5.7E+05	9.6E+04	1.2E+06
BMT	1.2E-07	8.5E+03	1.7E+03	-	1.0E+04	-	2.0E+04
NOCF	6.1E-06	2.1E+05	1.0E+04	-	2.7E+05	6.0E+03	4.9E+05

Note: Dashes represent MACCS results that are identically zero.

Table 4-57 Conditional Mean (Over All Weather Trials) Economic Costs within 100 Miles for Agricultural Restrictions (2015$)

Release Category	Freq (/yr)	Crop Disposal	Milk Disposal	Farmland Decon	Farmland Interdiction	Farmland Condemn.	Total Farm-Dependent
ISLOCA	1.3E-07	5.1E+08	1.2E+07	-	4.2E+08	1.4E+08	1.1E+09
CIF	1.7E-06	8.0E+08	1.2E+07	-	7.0E+08	3.7E+08	1.9E+09
COPEN-RCSINTACT	2.7E-07	1.3E+09	1.9E+07	-	1.0E+09	1.4E+09	3.7E+09
COPEN-RCSVENT	1.3E-07	1.1E+09	1.6E+07	-	5.8E+08	3.5E+09	5.2E+09
COPEN-HEADOFF	7.8E-08	1.3E+09	1.8E+07	-	7.6E+08	3.7E+09	5.7E+09
ECF	5.1E-10	4.3E+08	1.1E+07	-	3.3E+08	4.6E+07	8.2E+08
CF-Before-CD	2.1E-06	9.5E+08	1.4E+07	-	8.0E+08	9.4E+08	2.7E+09
ICF-BURN	1.7E-06	2.5E+08	1.1E+07	-	1.9E+08	1.9E+07	4.7E+08
LCF	5.5E-08	4.7E+05	3.6E+04	-	5.7E+05	9.6E+04	1.2E+06
BMT	1.2E-07	8.5E+03	1.7E+03	-	1.0E+04	-	2.0E+04
NOCF	6.1E-06	2.1E+05	1.0E+04	-	2.7E+05	6.0E+03	4.9E+05

Note: Dashes represent MACCS results that are identically zero.

Table 4-58 Conditional Mean (Over All Weather Trials) Economic Costs within 50 Miles for Population Restrictions (2015$)

Release Category	Freq (/yr)	Emergency Phase	Intermediate Phase	Population Dependent Decon	Population Dependent Interdiction	Population Dependent Condemn.	Total Population Dependent
ISLOCA	1.3E-07	1.3E+08	4.2E+08	1.7E+08	1.7E+09	1.8E+06	2.4E+09
CIF	1.7E-06	9.2E+07	1.0E+09	4.5E+08	4.7E+09	4.0E+06	6.3E+09
COPEN-RCSINTACT	2.7E-07	3.2E+08	8.7E+09	1.9E+09	1.8E+10	5.4E+07	2.9E+10
COPEN-RCSVENT	1.3E-07	4.3E+08	1.3E+10	4.9E+09	2.7E+10	7.3E+08	4.5E+10
COPEN-HEADOFF	7.8E-08	3.0E+08	9.4E+09	5.1E+09	2.5E+10	5.1E+08	4.0E+10
ECF	5.1E-10	1.3E+08	3.9E+08	9.3E+06	5.7E+08	-	1.1E+09
CF-Before-CD	2.1E-06	9.7E+07	3.5E+09	1.4E+09	1.2E+10	1.9E+07	1.7E+10
ICF-BURN	1.7E-06	1.3E+08	8.3E+08	1.7E+06	1.1E+09	-	2.0E+09
LCF	5.5E-08	3.1E+07	5.9E+03	1.5E+03	2.2E+04	-	3.1E+07
BMT	1.2E-07	2.5E+07	-	-	-	-	2.5E+07
NOCF	6.1E-06	3.1E+07	-	2.2E+01	1.7E+02	-	3.1E+07

Note: Dashes represent MACCS results that are identically zero.

Table 4-59 Conditional Mean (Over All Weather Trials) Economic Costs within 100 Miles for Population Restrictions (2015$)

Release Category	Freq (/yr)	Emergency Phase	Intermediate Phase	Population Dependent Decon	Population Dependent Interdiction	Population Dependent Condemn.	Total Population Dependent
ISLOCA	1.3E-07	1.3E+08	4.2E+08	1.7E+08	1.8E+09	1.8E+06	2.5E+09
CIF	1.7E-06	9.2E+07	1.0E+09	4.6E+08	4.8E+09	4.0E+06	6.4E+09
COPEN-RCSINTACT	2.7E-07	3.5E+08	1.7E+10	2.7E+09	3.5E+10	5.4E+07	5.5E+10
COPEN-RCSVENT	1.3E-07	7.4E+08	3.4E+10	1.0E+10	7.8E+10	7.3E+08	1.2E+11
COPEN-HEADOFF	7.8E-08	3.8E+08	2.2E+10	9.5E+09	7.0E+10	5.1E+08	1.0E+11
ECF	5.1E-10	1.3E+08	3.9E+08	9.3E+06	5.7E+08	-	1.1E+09
CF-Before-CD	2.1E-06	9.7E+07	3.8E+09	1.6E+09	1.5E+10	1.9E+07	2.1E+10
ICF-BURN	1.7E-06	1.3E+08	8.4E+08	1.7E+06	1.1E+09	-	2.0E+09
LCF	5.5E-08	3.1E+07	5.9E+03	1.5E+03	2.2E+04	-	3.1E+07
BMT	1.2E-07	2.5E+07	-	-	-	-	2.5E+07
NOCF	6.1E-06	3.1E+07	-	2.2E+01	1.7E+02	-	3.1E+07

Note: Dashes represent MACCS results that are identically zero.

The release category frequency-weighted relative contribution of different protective actions in the early, intermediate, and late (recovery) phases within 50 and 100 miles is shown in Figure 4-48 and Figure 4-49, respectively. Consistent with the results observed in Section 4.6 of NRC (2022a), population-dependent costs appear to be the largest contributor to costs. Figure 4-48 and Figure 4-49 suggest that interdiction and decontamination of property in the intermediate- and long-term phases, as well as daily costs from relocation of large numbers of persons in the intermediate phase, may result in significant costs.

The relative contribution of different release categories to the total frequency-weighted costs within 50 and 100 miles are shown in Figure 4-50 and Figure 4-51, respectively. These figures suggest that—like many other measures (such as collective dose, total latent cancer fatalities, land contamination, and affected populations)—the frequency-weighted economic costs are dominated by the CF-Before-CD, CIF, COPEN-RCSINTACT, COPEN-RCSVENT, and COPEN-HEADOFF release categories. The similarity of this figure to Figure 3-3, showing the relative contribution of release categories to the conditional mean frequency-weighted cesium release fraction, suggests that the magnitude of the cesium release fraction is important in determining the extent of economic costs.

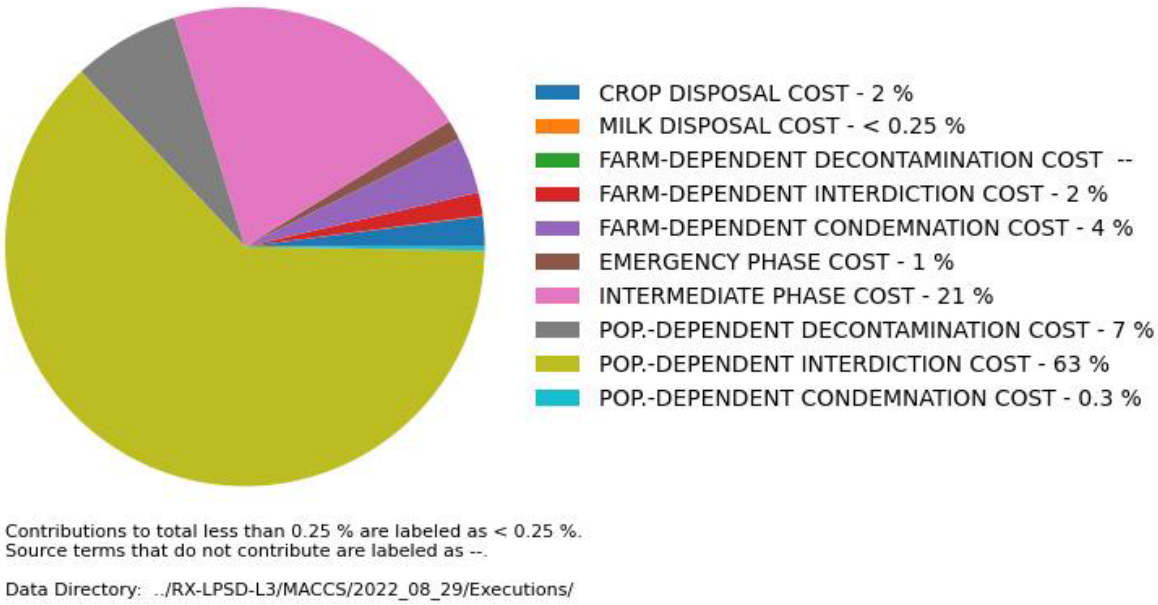


Figure 4-48 Relative Contribution of Protective Actions to Conditional Mean (Over All Weather Trials) Total Frequency-Weighted Economic Costs within 50 Miles

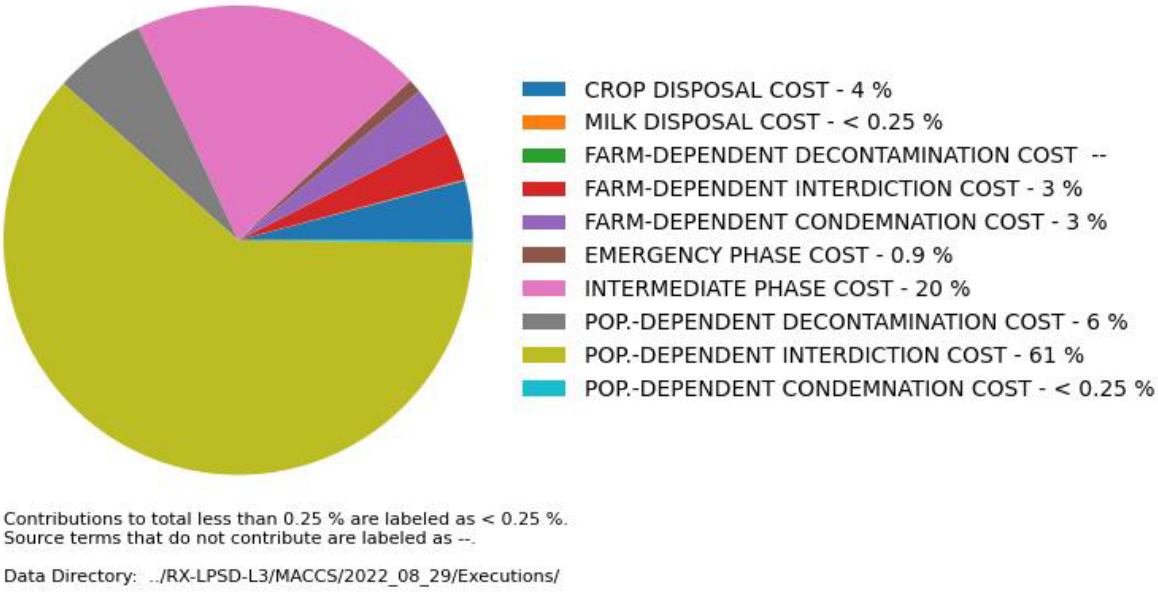


Figure 4-49 Relative Contribution of Protective Actions to Conditional Mean (Over All Weather Trials) Total Frequency-Weighted Economic Costs within 100 Miles

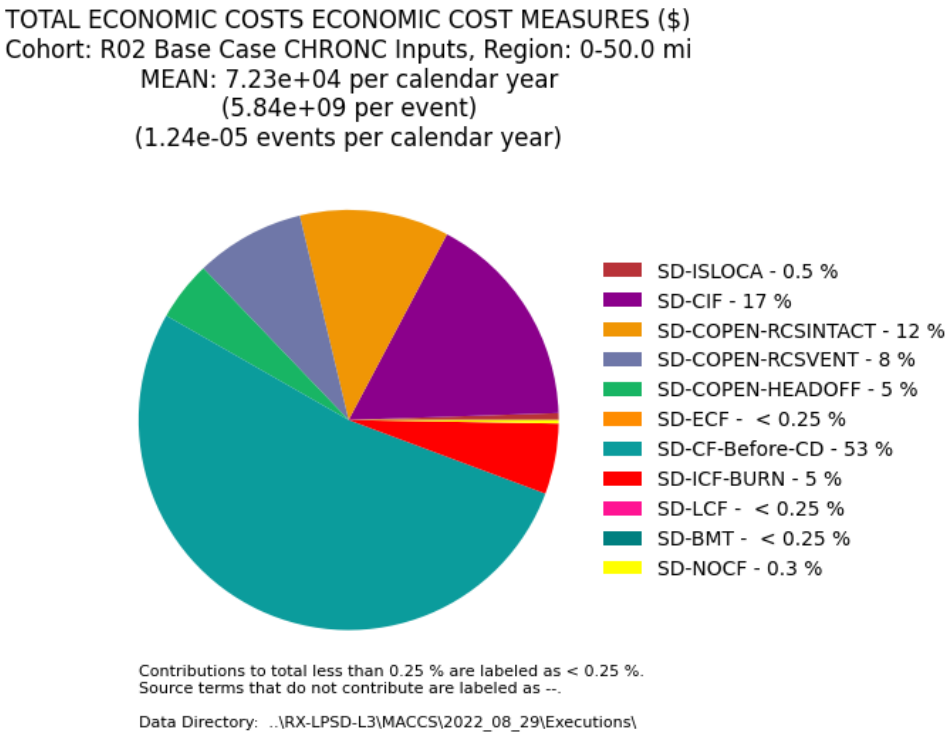


Figure 4-50 Relative Contribution of Release Categories to Conditional Mean (Over All Weather Trials) Total Frequency-Weighted Economic Costs within 50 Miles

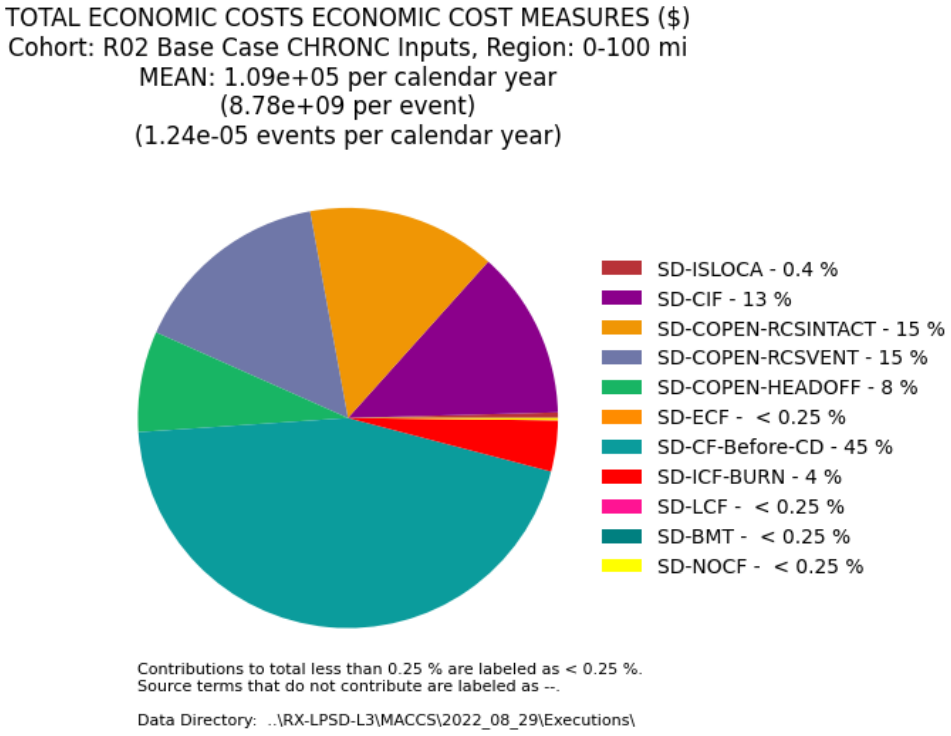


Figure 4-51 Relative Contribution of Release Categories to Conditional Mean (Over All Weather Trials) Total Frequency-Weighted Economic Costs within 100 Miles

The conditional mean total economic costs within 50 and 100 miles as a function of cesium release magnitude are shown in Figure 4-52. The comparable values from the reactor, at-power, internal events and internal floods (IEIF) release categories, based on data from Table 4-4 of NRC (2022a), are shown for comparison. This figure suggests that the total economic costs are closely related to the magnitude of the cesium release fraction across a wide range of release magnitudes. Much like the dependence of the intermediate-phase population on cesium release magnitude shown in Figure 4-39, there is relatively little difference between the 50- and 100-mile results until the release magnitude exceeds several MCi of cesium, at which point the contribution of results beyond 50 miles become increasingly significant. The apparent plateau at lower release magnitudes (less than 0.1 MCi total cesium) arise from the difference in the relationship between early-phase costs and total release magnitude versus the relationship between late-phase costs and total release magnitude. Figure 4-53 illustrates the relationship between the early-phase costs within 100 miles, the farmland costs within 100 miles, and the population-dependent late-phase costs within 100 miles. The comparable values from the IEIF release categories, based on data from Tables 4.6-2 and 4.6-4 of NRC (2022a), are shown for comparison. It may be seen that early-phase costs are dominant at lower release magnitudes, but rise more slowly than either farmland-dependent costs or late-phase population-dependent costs. It may also be seen that farmland-dependent costs rise more slowly than late-phase population-dependent costs, such that population-dependent costs are dominant at release magnitudes greater than a few tenths of a megacurie of cesium.

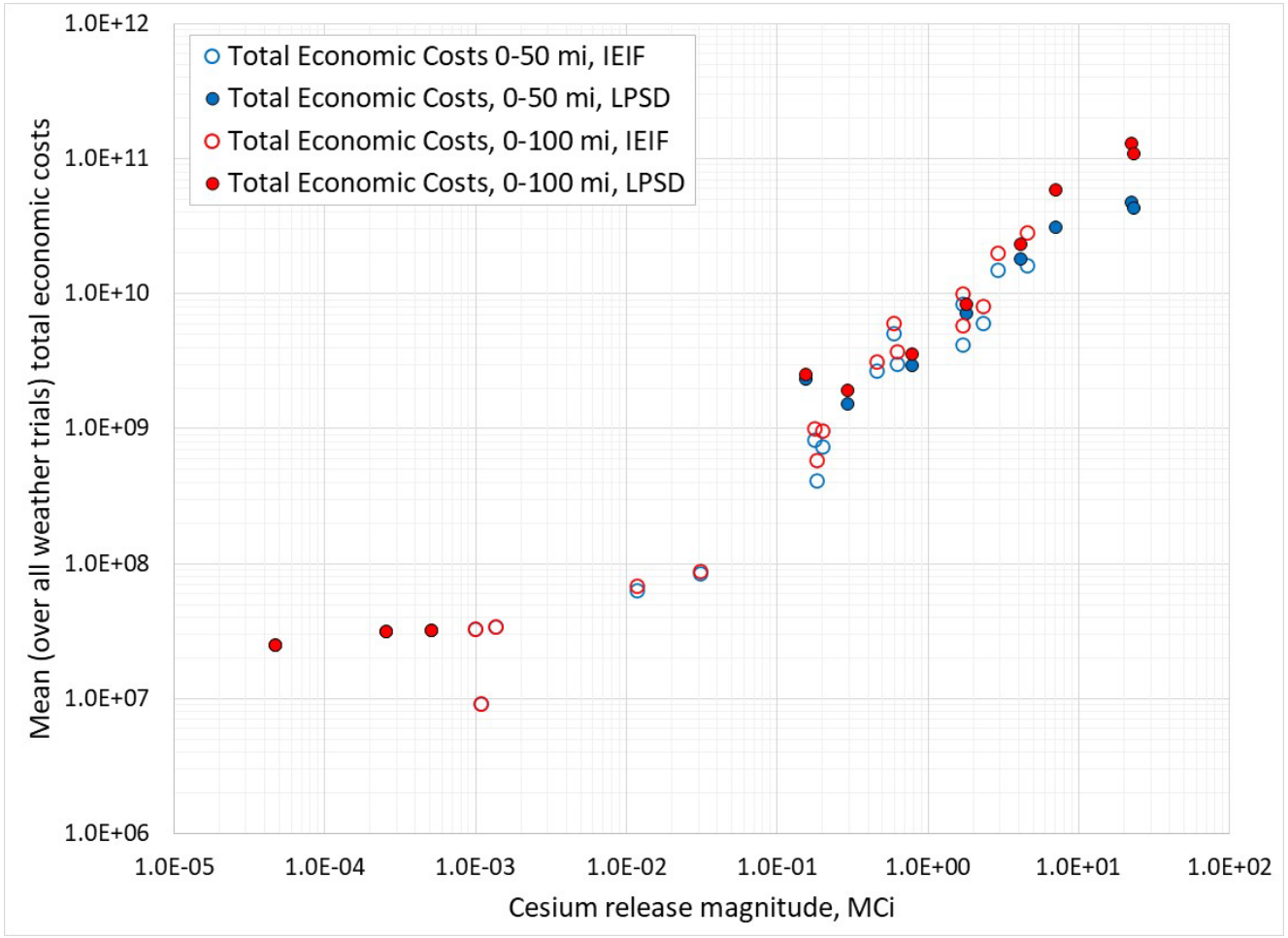


Figure 4-52 Conditional Mean (Over All Weather Trials) Total Economic Costs (2015$) within 50 and 100 Miles as a Function of Cesium Release Magnitude

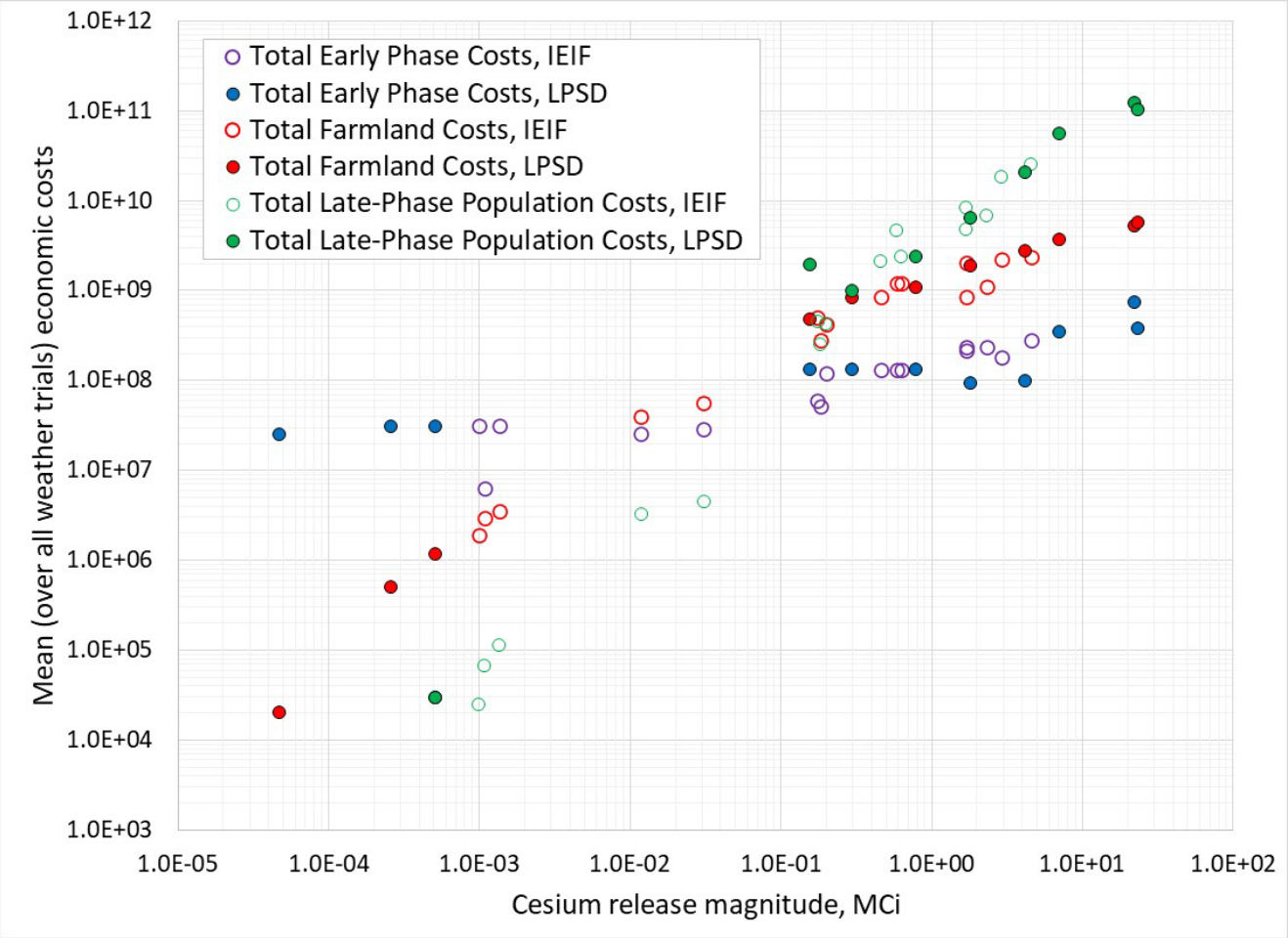


Figure 4-53 Conditional Mean (Over All Weather Trials) Total Economic Costs (2015$) by Type within 100 Miles as a Function of Cesium Release Magnitude

The relative contribution of different weather bins and release categories to the conditional mean value of the population within 100 miles subject to intermediate-phase relocation was also examined. Consistent with Section 4.6 of NRC (2022a), no pronounced difference in the relative contribution of release categories across different weather bins is particularly noticeable and the corresponding figures are therefore not reproduced here.

The CCDFs for conditional mean total economic costs within 50 and 100 miles are shown in Figure 4-54 and Figure 4-55, respectively. Inspection of these figures shows an interesting feature related to costs that is consistent with that observed in the at-power release categories; namely, that the costs associated with the NOCF and BMT release categories do not appear to be strongly dependent on meteorological variability. That is, the CCDF curves for these release categories show very little variability, as seen by the relatively rapid drop-off in the frequency of exceeding a value of 50 million 2015$. For the LPSD release scenarios, the LCF release category demonstrates a similar behavior. A possible explanation for this effect is that for these scenarios, which are dominated by early-phase costs, the size of (and therefore the costs associated with) the evacuated population may be relatively independent of weather (i.e., most of the full 10-mile EPZ is evacuated regardless of the meteorological conditions). This effect may also be seen in Table 4-3, where these two scenarios, despite having different release magnitudes, show very similar total economic costs. Table 4-58 and Figure 4-53 confirm this interpretation, showing the dominant contribution of early-phase costs for these lower-magnitude release categories.

The difference between the 50- and 100-mile economic results can be examined in Figure 4-52, as well as Figure 4-54 and Figure 4-55. Inspection of these figures, as well as the results in the tables, show that for lower release magnitudes, there does not appear to be a significant difference in the 50- and 100-mile costs, suggesting that most of the economic impacts are within 50 miles. For higher magnitude releases (greater than several megacuries of total cesium release), the results begin to diverge, suggesting additional impacts beyond 50 miles.

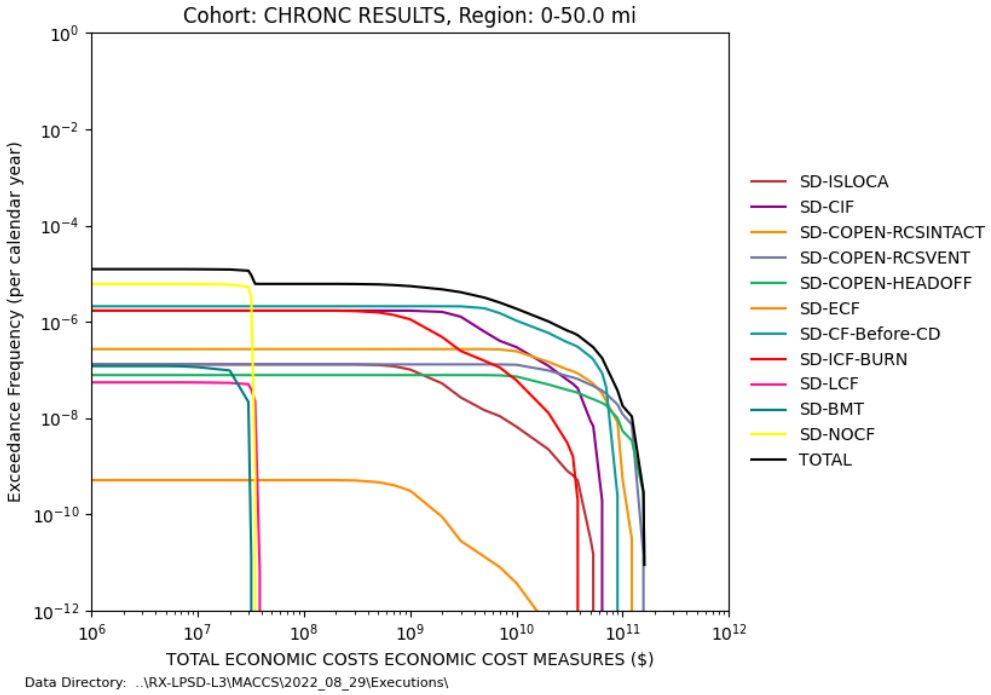


Figure 4-54 Complementary Cumulative Distribution Function of Total Economic Costs within 50 Miles

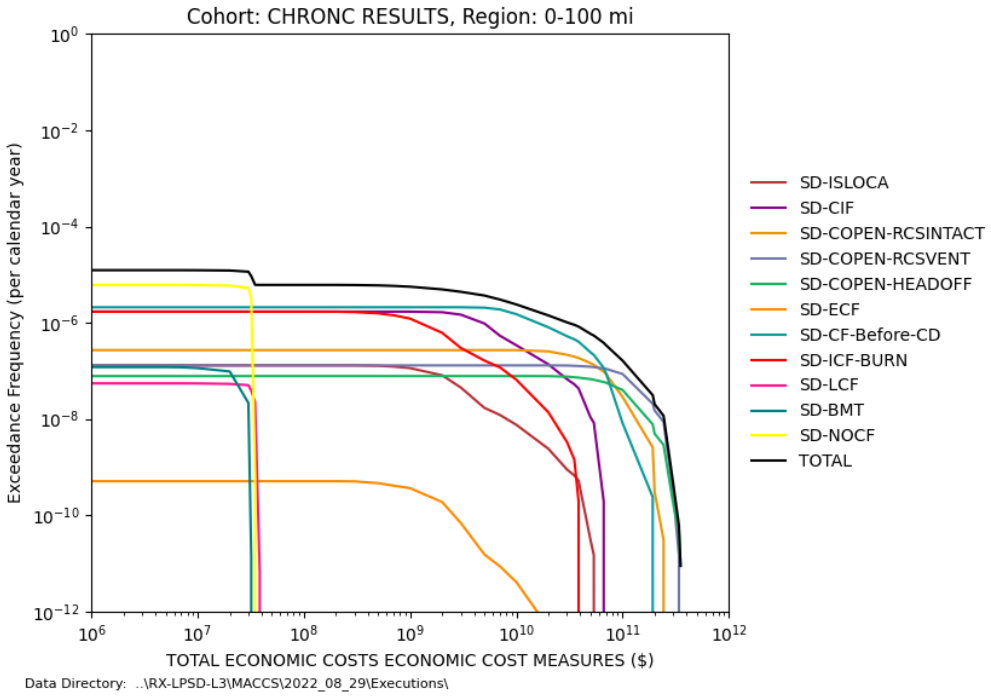


Figure 4-55 Complementary Cumulative Distribution Function of Total Economic Costs within 100 Miles

4.6.1 Sensitivity Cases

4.6.1.1 Meteorological Sampling

The effect of sampling only a subset of the meteorological data on the total economic costs within 80 and 161 km (50 and 100 mi) is demonstrated in Table 4-60 and Table 4-61, respectively. It is evident from inspection of these results that differences resulting from sampling a representative subset of weather trials as opposed to sampling all 8,760 hourly observations are generally less than a few percent.

Table 4-60 Summary of Total Economic Costs, 0–50 Miles (2015$) (Conditional Mean Value Across All Weather Trials): ME_2

Release Category	Frequency (/yr)	Base Case	ME_2	Fraction of Base Case[2]
ALL[1] (per yr)	**1.2E-05**	**7.2E+04**	**7.0E+04**	**0.971**
ISLOCA	1.3E-07	2.9E+09	3.0E+09	1.027
CIF	1.7E-06	7.1E+09	6.9E+09	0.968
COPEN-RCSINTACT	2.7E-07	3.1E+10	3.1E+10	0.990
COPEN-RCSVENT	1.3E-07	4.7E+10	4.6E+10	0.989
COPEN-HEADOFF	7.8E-08	4.2E+10	4.1E+10	0.974
ECF	5.1E-10	1.5E+09	1.6E+09	1.040
CF-Before-CD	2.1E-06	1.8E+10	1.7E+10	0.950
ICF-BURN	1.7E-06	2.3E+09	2.5E+09	1.095
LCF	5.5E-08	3.2E+07	3.2E+07	0.997
BMT	1.2E-07	2.5E+07	2.5E+07	1.004
NOCF	6.1E-06	3.1E+07	3.1E+07	0.997

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of base case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded base case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Table 4-61 Summary of Total Economic Costs, 0–100 Miles (2015$) (Conditional Mean Value Across All Weather Trials): ME_2

Release Category	Frequency (/yr)	Base Case	ME_2	Fraction of Base Case[2]
ALL[1] (per yr)	**1.2E-05**	**1.1E+05**	**1.1E+05**	**0.983**
ISLOCA	1.3E-07	3.6E+09	3.6E+09	1.020
CIF	1.7E-06	8.3E+09	8.0E+09	0.970
COPEN-RCSINTACT	2.7E-07	5.9E+10	5.8E+10	0.991
COPEN-RCSVENT	1.3E-07	1.3E+11	1.3E+11	1.000
COPEN-HEADOFF	7.8E-08	1.1E+11	1.1E+11	1.000
ECF	5.1E-10	1.9E+09	2.0E+09	1.031
CF-Before-CD	2.1E-06	2.3E+10	2.2E+10	0.966
ICF-BURN	1.7E-06	2.5E+09	2.7E+09	1.080
LCF	5.5E-08	3.2E+07	3.2E+07	0.997
BMT	1.2E-07	2.5E+07	2.5E+07	1.004
NOCF	6.1E-06	3.1E+07	3.1E+07	0.997

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of base case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded base case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

4.6.1.2 Accident Termination Time

The effect of terminating the accident release 36 hours after SAMG entry on economic costs within 80 and 161 km (50 and 100 mi) is demonstrated in Table 4-62 and Table 4-63, respectively. For sensitivity analysis, only a subset of weather trials was sampled to increase computational efficiency. For this case, the reference case values are therefore the results from ME_2 described in the previous section. These values were selected for the reference case to minimize confounding effects from weather sampling with the effect of accident termination time.

The effect of terminating the release is a slight reduction in the economic costs. On a frequency-weighted basis, the reduction is less than 15 percent. Some release categories (such as ISLOCA or CIF) are relatively unaffected, with a reduction on the order of a few percent, whereas other release categories (such as ECF and ICF-BURN) are reduced by over 99 percent. The COPEN-RCSVENT and COPEN-RCSINTACT release categories are noticeably affected, with reductions on the order of 20–40 percent.

The differential impact of the accident termination time on the relative contribution of release categories to the economic costs within 80 and 161 km (50 and 100 mi) is illustrated in Figure 4-56 and Figure 4-57, respectively. The frequency-weighted reduction in the economic costs is a combination of the much lower conditional consequences for the ICF release category, with a noticeable (greater than 30 percent) reduction in the conditional consequences for the COPEN-RCSVENT and COPEN-RCSINTACT release categories. The relative contribution of release categories to the economic costs is similar to the relative contribution of release categories to the cumulative cesium release shown in Figure 4-1, with the CIF and CF-Before-CD release categories increasing in relative importance and the ICF release category comprising a much smaller contributor.

Table 4-62 Summary of Total Economic Costs, 0–50 Miles (2015$) (Conditional Mean Value Across All Weather Trials): RE_4

Release Category	Frequency (/yr)	Reference Case (ME_2)	RE_4	Fraction of Reference Case[2]
ALL[1] (per yr)	**1.2E-05**	**7.0E+04**	**6.2E+04**	**0.878**
ISLOCA	1.3E-07	3.0E+09	2.9E+09	0.957
CIF	1.7E-06	6.9E+09	6.8E+09	0.988
COPEN-RCSINTACT	2.7E-07	3.1E+10	2.0E+10	0.666
COPEN-RCSVENT	1.3E-07	4.6E+10	3.8E+10	0.819
COPEN-HEADOFF	7.8E-08	4.1E+10	4.1E+10	0.990
ECF	5.1E-10	1.6E+09	2.4E+07	0.016
CF-Before-CD	2.1E-06	1.7E+10	1.7E+10	0.994
ICF-BURN	1.7E-06	2.5E+09	1.2E+07	0.005
LCF	5.5E-08	3.2E+07	2.0E+07	0.624
BMT	1.2E-07	2.5E+07	1.2E+07	0.474
NOCF	6.1E-06	3.1E+07	2.0E+07	0.645

1. Results are a frequency-weighted sum of all release categories.

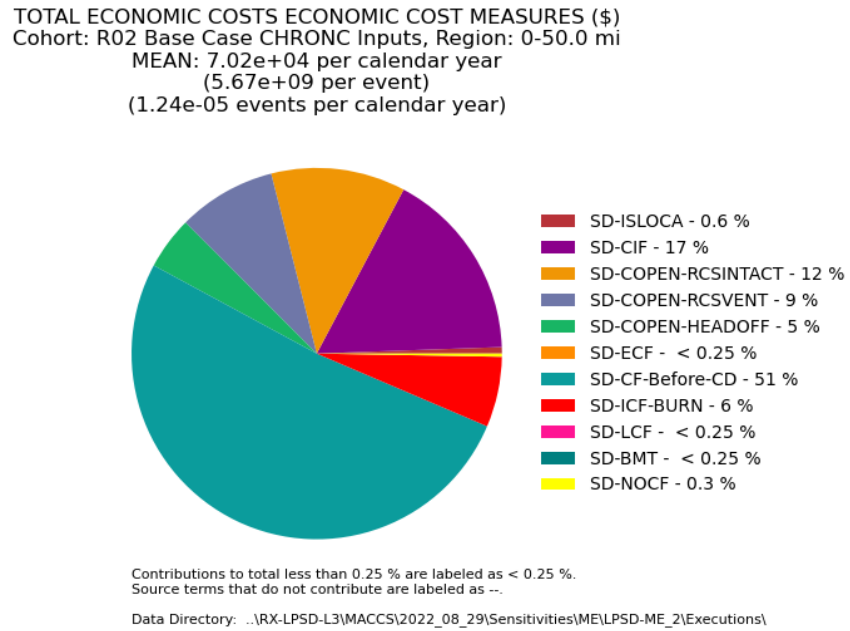
2. Fraction of reference case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded reference case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

Table 4-63 Summary of Total Economic Costs, 0–100 Miles (2015$) (Conditional Mean Value Across All Weather Trials): RE_4

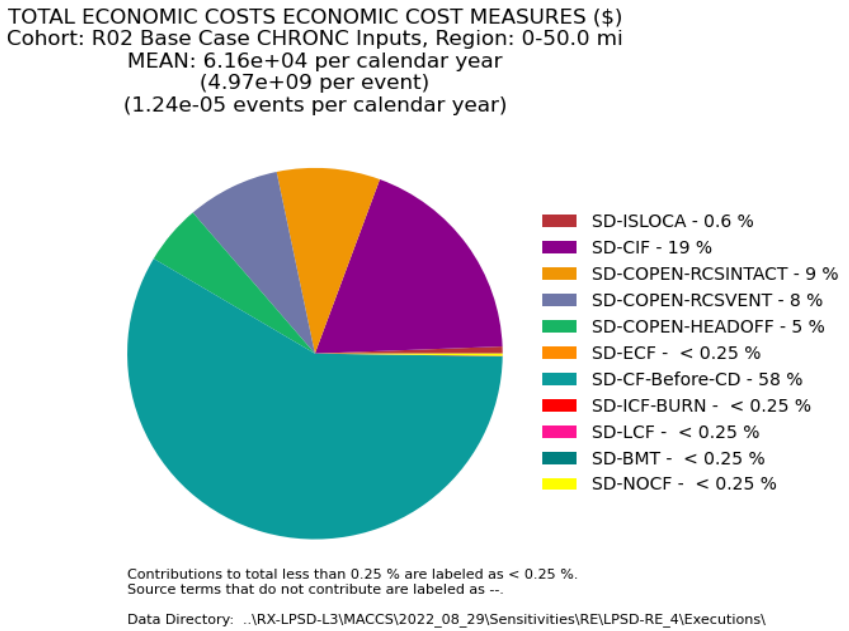
Release Category	Frequency (/yr)	Reference Case (ME_2)	RE_4	Fraction of Reference Case[2]
ALL[1] (per yr)	**1.2E-05**	**1.1E+05**	**9.2E+04**	**0.864**
ISLOCA	1.3E-07	3.6E+09	3.5E+09	0.956
CIF	1.7E-06	8.0E+09	7.9E+09	0.989
COPEN-RCSINTACT	2.7E-07	5.8E+10	3.3E+10	0.576
COPEN-RCSVENT	1.3E-07	1.3E+11	1.1E+11	0.837
COPEN-HEADOFF	7.8E-08	1.1E+11	1.1E+11	0.991
ECF	5.1E-10	2.0E+09	2.4E+07	0.012
CF-Before-CD	2.1E-06	2.2E+10	2.2E+10	0.996
ICF-BURN	1.7E-06	2.7E+09	1.2E+07	0.005
LCF	5.5E-08	3.2E+07	2.0E+07	0.624
BMT	1.2E-07	2.5E+07	1.2E+07	0.474
NOCF	6.1E-06	3.1E+07	2.0E+07	0.645

1. Results are a frequency-weighted sum of all release categories.

2. Fraction of reference case was calculated based on full-precision code outputs. Estimation of the ratio based on the rounded reference case and sensitivity results in this table may result in a larger (or smaller) difference than that computed from the actual code outputs.

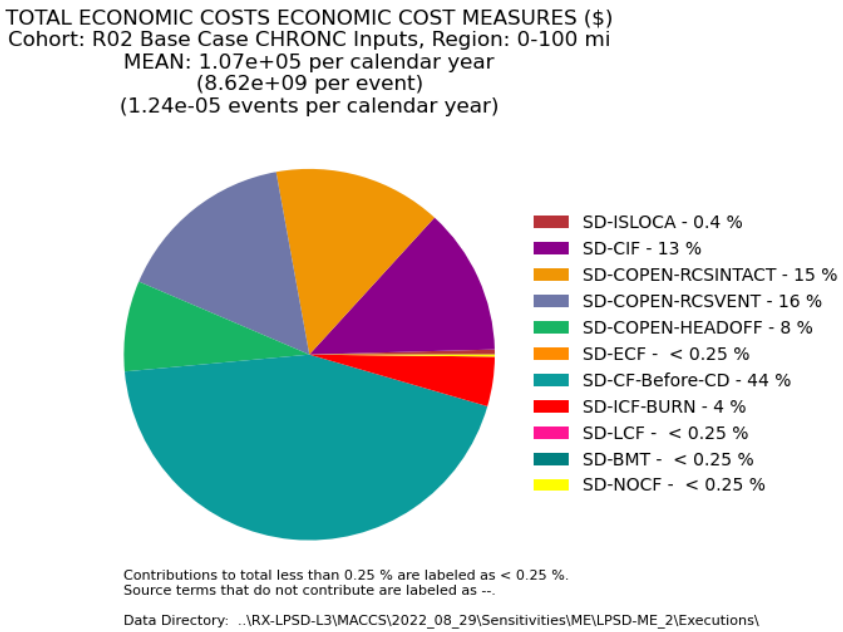


Reference Case (ME_2)

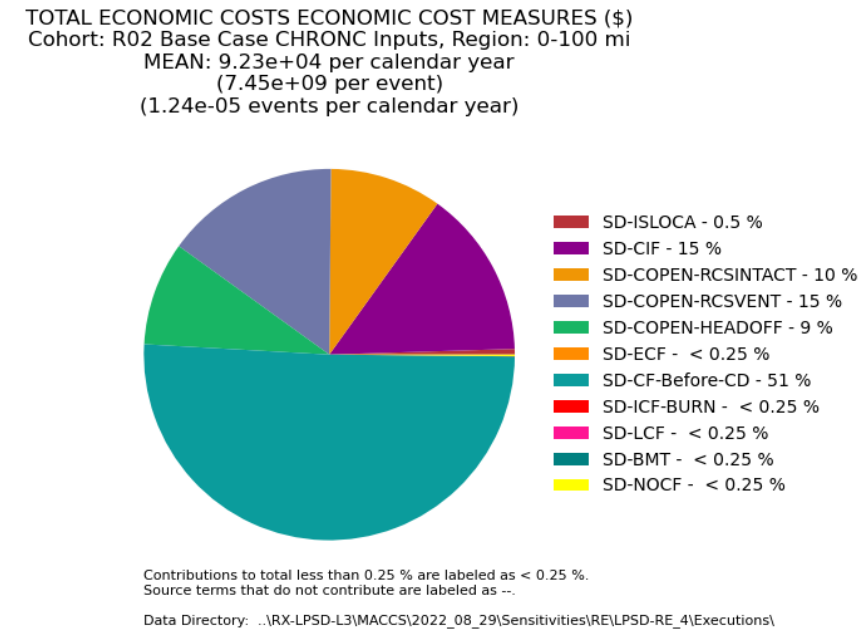


RE_4

Figure 4-56 Relative Contribution of Release Categories to Total Economic Costs, 0–50 Miles (2015$): RE_4



Reference Case (ME_2)



RE_4

Figure 4-57 Relative Contribution of Release Categories to Total Economic Costs, 0–100 Miles (2015$): RE_4

4.6.1.3 Low-Dose Cancer Risk Estimation

Inspection of the results for the estimated total economic costs arising from the use of a model that estimates cancer risk based only on annual individual doses greater than 0.05 Sv (5 rem), or lifetime individual doses greater than 0.1 Sv (10 rem), shows that (as expected) there is no significant difference between the results of the reference case and the results for sensitivity case HE-2. For this sensitivity analysis, only a subset of weather trials was sampled to increase computational efficiency. For this case, the reference case values are therefore the results from ME_2 described previously. These values were selected for the reference case to minimize confounding effects from weather sampling with the effect of using a dose truncation model. The ratio of the results of the reference and sensitivity case were 1.000 for all release categories and are therefore not reproduced here.

4.7 Results Summary

Like the results observed for the at-power scenarios, effectively no populations were projected to receive the high doses needed for the induction of early health effects. Only the COPEN-RCSVENT and COPEN-HEADOFF release categories resulted in non-zero early fatality risk, and this risk was extremely small and limited to the non-evacuating cohort. This results in the bulk of the radiological exposure arising from reoccupation of land after decontamination and natural decay and weathering reduce exposures to levels below the habitability criteria assumed in the analysis (i.e., 2 rem in the year of the accident and 500 mrem per year in the years after the accident). These levels are in the low to very low dose range. As discussed in Volume 4, Annex X of IAEA (2015), these levels would give rise to a small hypothetical additional lifetime risk of cancer (less than 0.1 percent). From an epidemiological standpoint, the number of latent cancer fatalities attributable to radiation exposure from accidental releases from a severe accident would unlikely be observable statistically above the expected number of cancer fatalities in the exposed population from all other causes (i.e., the excess cancer fatalities predicted are too few to allow the detection of a statistically significant difference in the cancer fatalities expected from other causes among the same population). The examination of early fatality risk (or comparably, the risk of high exposures) suggests that the extremely low likelihood of high doses to the offsite public are because of the following factors:

- very low frequency of events that would generate relatively large and fast releases.
- relatively low frequency of adverse meteorological conditions (primarily stable, low wind speed conditions)
- very sparse close-in population, which limits the likelihood of the wind blowing in the direction of a populated sector very close to the site
- low likelihood of delayed and/or slow evacuation of the populations toward which the winds are blowing

These results are, of course, site-specific. Sites for which these factors are less applicable (i.e., higher close-in population densities, coupled with higher likelihood of slow or delayed evacuations) may experience a higher risk of elevated exposures.

Like the at-power scenarios, the collective effects (collective effective dose, economic impacts, contaminated land area, affected population size, etc.) for this analysis appear largely to be

driven by the magnitude of the release of the volatile fission products, particularly cesium. Across a range of collective effects, there is a strong relationship between the projected conditional mean value of these types of measures and the cesium release magnitude, as shown in the figures in Section 4.4, Section 4.5, and Section 4.6. The relationship is similar regardless of whether the release is from an at-power scenario or an LPSD scenario. It may be noted that all three of the open containment release categories, representing approximately 4 percent of the total LPSD release frequency, result in cesium releases larger than the largest at-power cesium release. As shown in Figure 4.3-8, these large releases do not result in increases in the individual latent fatality risk within 10 miles, but they do result in increases in the extent of long-term protective actions that would be needed (see, for example, Figure 4-39 and Figure 4-52).

It may be noted that for many release categories, the total economic and affected population measures are very similar between 0–50 miles and 0–100 miles. However, for the larger releases (greater than approximately 1 MCi of cesium) the results begin to diverge, suggesting additional impacts beyond 50 miles. For many of the larger releases, the differences are less than a factor of 2, suggesting that most of the economic impacts will occur within 50 miles for the types of source terms considered here. However, the largest release (the COPEN-HEADOFF release category with a 24-MCi cesium release) shows increases in impacted population sizes and economic damages greater than a factor of 2, suggesting that for releases larger than approximately 10–20 MCi of cesium, most impacted populations and economic impacts may be beyond 50 miles.

5 RISK INTEGRATION

The following discussion is abridged from Section 5 of NRC (2022a) and revised to discuss the consequences associated with the LPSD release categories. It should be noted that source term frequencies for LPSD events are given in terms of calendar-years, whereas release category frequencies for reactor at-power events are typically given in terms of reactor-years. The number of reactor-years accumulated by a single reactor during a calendar-year is slightly less than 1 reactor-year because, on average, the reactor will be shut down for at least part of the year (i.e., the plant availability factor will be less than 1.0). To convert the release frequency of the ***reactor at-power*** from per reactor-year to per calendar-year, multiply the frequency by the plant availability factor of 0.93. However, it should be noted that the resulting reactor, at-power, calendar-year release frequency does not include the contribution from reactor shutdown operations during the calendar year.

The influence of uncertainties in Level 1 and Level 2 PRA event tree and fault tree modeling for the LPSD analysis is considered in this section. The set of offsite public risk metrics that are addressed in this section are identified in Table 5-1. The remainder of this section is comprised of seven subsections. Sections 5.1 through 5.6 presents results for offsite public risk metrics related to six main categories of offsite radiological consequences: (1) doses to the offsite public (Section 5.1), (2) early health effects (Section 5.2), (3) latent health effects (Section 5.3), (4) land contamination (Section 5.4), (5) affected population (Section 5.5), and (6) economic costs (Section 5.6). A summary of the risk integration task is provided in Section 5.7.

Table 5-1 Set of Offsite Public Risk Metrics Analyzed

No.	Offsite Public Risk Metric	Spatial Interval
1	Population Dose Risk	0–50 miles 0–100 miles
2	Population-Weighted Individual Early Fatality Risk	0-1.8 miles[1]
3	Total Early Fatality Risk	0–50 miles
4	Population-Weighted Individual Latent Cancer Fatality Risk	0–10 miles
5	Total Latent Cancer Fatality Risk	0–50 miles 0–100 miles
6	Land Contamination Risk (Area Exceeding 555 kBq/m^2 [15 Ci/km^2] Cs-137)	0–50 miles 0–100 miles
7	Intermediate-Phase Population Relocation Risk	0–50 miles 0–100 miles
8	Economic Cost Risk	0–50 miles 0–100 miles

[1] *The 0-1.8-mile spatial interval is used to model the region out to 1 mile beyond the site boundary for the reference nuclear power plant site. The exclusion area boundary (EAB) is approximately 0.75 miles from the modeled reactor located at the origin of the radial spatial grid in MACCS.*

5.1 Doses to the Offsite Public

The following discussion is abridged from Section 5.3 of NRC (2022a) and revised to discuss the risks from events initiated during LPSD operations. Population dose risk is calculated using the MACCS Type 5 output and reported over two spatial intervals around the reference nuclear power plant: (1) 0–50 miles, and (2) 0–100 miles.

As shown in Table 4-1, as reproduced in Table 5-2, the frequency-weighted mean annual population dose (total effective dose) risk within 50 miles is 3.6 person-rem per calendar-year, and the frequency-weighted mean annual population dose (total effective dose) risk within 100 miles is 8.9 person-rem per calendar-year. These values were obtained by weighting the conditional mean (over all weather trials) consequence values for individual release categories by the point estimate of the individual release category frequencies. Also shown for comparison in Table 5-2 are the summary population dose risk measures from at-power scenarios, adapted from Table 5-2 of NRC (2023). It may be noted that the population dose risk values for LPSD scenarios are slightly over one-third of those from the reactor, at-power, internal events and internal floods scenarios and less than one-fifth of the total at-power population dose risk.

Table 5-2 Summary of Population Dose Risk Measures

Scope Piece	Release Freq. (/yr)	Collective Total Effective Dose Risk (person-rem/yr), 0–50 miles[1]	Collective Total Effective Dose Risk (person-rem/yr), 0–100 miles[1]
LPSD (Internal events)	1.2E-05	3.6	8.9
At-Power (Internal events and internal floods)	6.4E-05[2]	9.2	19
At-Power (All hazards[3])	1.6E-04[2]	25	50

[1] *Results are a frequency-weighted sum of all release categories. Reactor at-power results are based on reactor-years. To convert the risk metric of the **reactor at-power** from per reactor-year to per calendar-year, multiply the result by the plant availability factor of 0.93. Note, the resulting reactor, at-power, calendar-year risk does not include the risk associated with reactor shutdown operations during the calendar year.*

[2] *Frequency of reactor at-power events are given in reactor-years. To convert the release frequency of the **reactor at-power** from per reactor-year to per calendar-year, multiply the frequency by the plant availability factor of 0.93. Note, the resulting reactor, at-power, calendar-year release frequency does not include the contribution from reactor shutdown operations during the calendar year.*

[3] *Includes at-power internal events, internal floods, internal fires, seismic events, and high-wind events.*

5.1.1 CCDF Curves and Summary Tables of Exceedance Frequencies

Figure 5-1 and Figure 5-2 display CCDF curves that illustrate the frequencies of exceeding specified levels of population dose within 50 miles and 100 miles of the reference nuclear power plant site, respectively. As shown in Figure 5-1 and Figure 5-2, the frequency initially decreases at levels of a few hundred person-rem, suggesting that most modeled core damage sequences resulted in population doses of at least several hundred person-rem. The slopes of the CCDF curves become more negative at 2×10^5 person-rem within 50 miles and at about 1×10^6 person-rem within 100 miles. The frequency of exceeding 2×10^6 person-rem drops precipitously. This indicates that although there is some increase in the collective dose as the region of interest extends beyond 50 miles, collective effective doses of greater than 2×10^5–1×10^6 person-rem are

increasingly unlikely and the frequency of collective effective doses of greater than 2×10^6 person-rem is vanishingly small.

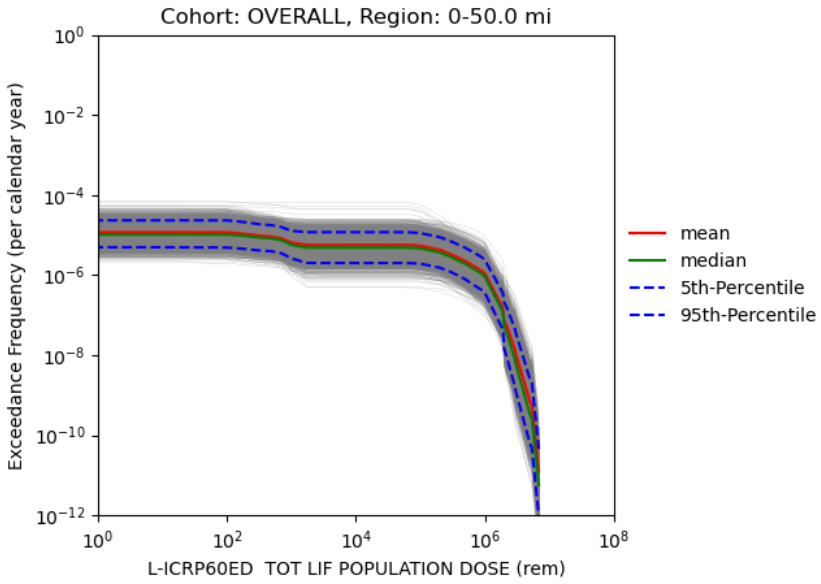


Figure 5-1 CCDF Curves of Uncertain Collective Total Effective Dose within the 0–50-Mile Interval (person-rem)

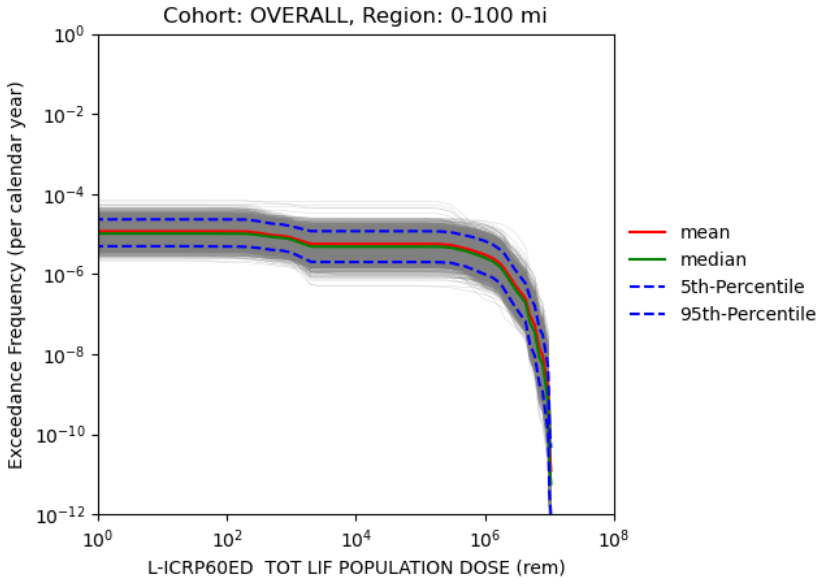


Figure 5-2 CCDF Curves of Uncertain Collective Total Effective Dose Within the 0–100-Mile Interval (person-rem)

CCDF curves are presented because they are consistent with PRA state-of-practice and were used in the NUREG-1150 summary report. Table 5-3 and Table 5-4 summarize the mean exceedance frequencies and the 90 percent probability intervals for the frequencies of exceeding specified population doses within 50 miles and 100 miles of the reference nuclear power plant site, respectively. These tables show that there is little difference between the results for the 0–50- and 0–100-mile regions, except for large population doses (e.g., 1×10^6 person-rem). Examination of Figure 5-1 and Figure 5-2 reveals that the maximum population dose across all modeled accident scenarios and all weather trials is about 7×10^6 for the 0–50-mile region and about 1×10^7 for the 0–100-mile region. This suggests that there are low-frequency accidents that could result in significant population doses that go beyond 50 miles.

Table 5-3 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Population Dose Levels (0–50 Miles)

Population Dose (0–50 miles) (person-rem)	Mean Exceedance Frequency (/yr)	Exceedance Frequency 90% Probability Interval (/yr)
10^4	5.7E-06	2.0E-06 – 1.2E-05
10^5	5.4E-06	1.9E-06 – 1.1E-05
10^6	1.1E-06	3.6E-07 – 2.4E-06

Table 5-4 Mean And 90% Confidence Intervals for Exceedance Frequencies of Specified Population Dose Levels (0–100 Miles)

Population Dose (0–100 miles) (person-rem)	Mean Exceedance Frequency (/yr)	Exceedance Frequency 90% Probability Interval (/yr)
10^4	5.7E-06	2.0E-06 – 1.2E-05
10^5	5.7E-06	2.0E-06 – 1.2E-05
10^6	3.1E-06	9.9E-07 – 6.7E-06

5.1.2 Significant Contributors to Risk

Figure 4-6 and Figure 4-7 illustrate the relative contributions of each modeled radiological release category to the mean annual risk of population dose within 50 miles and 100 miles, respectively. These figures show that the two release categories that make the largest contribution to mean annual risk of population dose within both 50 and 100 miles are: (1) a release category in which the containment fails due to overpressure by steam sometime in between the start of the accident and the start of core damage (SD-CF-Before-CD) and (2) a release category in which the release to the environment occurs via a containment penetration that fails to be isolated by manual action or via a pre-existing leakage path (not including open containment hatch or personnel airlock) (SD-CIF). These two radiological release categories collectively contribute around 70 percent of the mean annual risk of population dose within both 50 and 100 miles. Taken together, the three release categories that involve an open containment hatch and/or personnel airlock, with operator failure to reclose them (SD-COPEN-HEADOFF, SD-COPEN-RCSINTACT, SD-COPEN-RCSVENT), collectively contribute an

additional 16 percent (within 50 miles) to 21 percent (within 100 miles) of the mean annual risk of population dose. The release category in which the containment fails hours after vessel breach due to a global deflagration or detonation (SD-ICF-BURN) makes up the bulk of the remaining contribution (9–10 percent). Note, as discussed in Section 2.5.1 of NRC (2025), the release category binning scheme for the reactor at-shutdown does not differentiate based on the availability of fission product scrubbing since, unlike for the at-power PRA, it is not a key determiner of release timing and magnitude for the at-shutdown results.

A composite Fussell-Vesely (FV) importance[13] was calculated for each of the basic events in the integrated Level 1 and Level 2 PRA logic models. Virtually all the basis events that have a composite FV importance greater than 0.005 for mean annual risk of population dose within both 50 miles and 100 miles, for the reactor at-shutdown, are in common for both risk metrics.

Review of the composite FV importance rankings reveals that, for the reactor at-shutdown, LOOP is the initiating event contributing by far the most to mean annual risk of population dose within both 50 and 100 miles (nearly 80 percent). Other initiating event contributors with the reactor at-shutdown (all in the 5 percent range) include (1) loss of NSCW, (2) an overdraining event with the reactor in mid-loop operation, (3) loss of RHR, and (4) loss of a 4,160 V AC bus. Also, approximately 80 percent of mean annual risk of population dose within both 50 and 100 miles occurs in just two plant operating states (POSs), refueling operation (65 percent) or when the pressurizer is water solid for hydrogen degassing prior to refueling (15 percent).

Aside from the boundary condition basic events (i.e., related to plant operating type and state) and initiating events, most of the highest contributing events involve various human errors (e.g., failures to restore electric power, failure to establish low-pressure gravity feed given LOOP, or failure to diagnose and isolate a loss of inventory before the loss of RHR shutdown cooling). Other high contributing events include failures leading to a station blackout (e.g., failures of diesel generators, reserve auxiliary transformer [RAT] input breakers, or load sequencers) and events associated with combustion (detonations or deflagrations) within containment. Note, some combustion events result in direct failure of the containment, while others occur early in the accident progression before there is sufficient combustible gas to result in containment failure. In these latter cases, the early combustible events can reduce the amount of combustible gas in containment, thereby reducing the likelihood of a larger combustible event later in the accident progression. However, the most important factor influencing late combustion-induced containment failure is the success of late containment heat removal resulting in reduced steam concentrations. This action influences the likelihood of combustion events in the late timeframe to a greater extent than whether there were earlier combustion events.

[13] The composite FV importance measure for a particular basic event is used to represent the relative contribution to the total mean annual risk for each selected offsite public risk metric from accident scenarios that include that basic event. In practice, this composite FV importance measure is calculated as a weighted sum of the standard FV importance measure for the basic event with respect to each radiological release category frequency, weighted by the relative contribution of each radiological release category to the mean annual risk for each selected offsite public risk metric. A more complete discussion of this importance measure is provided in Section 5.2.5.1 of NRC (2022a).

5.2 Early Health Effects

The following discussion is abridged from Section 5.4 of NRC (2022a) and revised to discuss the risks from events initiated during LPSD operations. Two offsite public risk metrics pertaining to early health effects are calculated and reported. Population-weighted early fatality risk (0–1.8 miles), computed using the MACCS Type 8 output, measures the average annual risk to individuals within 1 mile of the site boundary of dying within 1 year from acute exposures to radiation due to modeled accidental releases of radiological materials from the reference nuclear power plant site. Results for this metric can be compared to the average individual early fatality risk quantitative health objective (QHO) to obtain insights related to the NRC's safety goal policy (NRC, 1986). Total early fatality risk (0–50 miles), computed using the MACCS Type 1 output, measures the total annual risk to society of deaths among the population within 50 miles occurring within 1 year from acute exposures to radiation due to modeled accidental releases of radiological materials from the reference nuclear power plant site.

As shown in Table 4-2, as reproduced in Table 5-5, the frequency-weighted mean annual population-weighted individual early fatality risk within 1 mile of the site boundary is 1.4×10^{-12} per calendar-year. The frequency-weighted mean annual risk of total early fatalities within 50 miles is 3.5×10^{-11} early fatalities per calendar-year. These values were obtained by weighting the conditional mean (over all weather trials) consequence values for individual release categories by the point estimate of the individual release category frequencies. Also shown for comparison in Table 5-5 are the summary early fatality risk measures from at-power scenarios, adapted from Table 5-9 of NRC (2023). It may be noted that the early fatality risk from LPSD scenarios for just internal events (almost completely due to the COPEN-RCSVENT release category) is almost twice as high as the risk from at-power scenarios for ***all*** hazards.

Table 5-5 Summary of Early Fatality Risk Measures

Scope Piece	Release Freq. (/yr)	Individual Early Fatality Risk, 0–1.8 mi (/yr)[1]	Early Fatality Cases, 0–50 mi (persons/yr)[1]
LPSD (Internal events)	1.2E-05	1.4E-12	3.5E-11
At-Power (Internal events and internal floods)	6.4E-05[2]	3.2E-13	8.1E-12
At-Power (All hazards[3])	1.6E-04[2]	7.0E-13	1.8E-11

[1] *Results are a frequency-weighted sum of all release categories. Reactor at-power results are based on reactor-years. To convert the risk metric of the **reactor at-power** from per reactor-year to per calendar-year, multiply the result by the plant availability factor of 0.93. Note, the resulting reactor, at-power, calendar-year risk does not include the risk associated with reactor shutdown operations during the calendar year.*

[2] *Frequency of reactor at-power events are given in reactor-years. To convert the release frequency of the **reactor at-power** from per reactor-year to per calendar-year, multiply the frequency by the plant availability factor of 0.93. Note, the resulting reactor, at-power, calendar-year release frequency does not include the contribution from reactor shutdown operations during the calendar year.*

[3] *Includes at-power internal events, internal floods, internal fires, seismic events, and high-wind events.*

5.2.1 CCDF Curves and Summary Tables of Exceedance Frequencies

Figure 5-3 displays sets of CCDF curves that illustrate the frequencies of exceeding specified levels of population-weighted early fatality risk for LPSD scenarios within 1.6 km (1 mi) of the site boundary. Likewise, Figure 5-4 displays sets of CCDF curves that illustrate the frequencies

of exceeding specified numbers of early fatalities within 80 km (50 mi). These curves show that early fatality risks are extremely low.

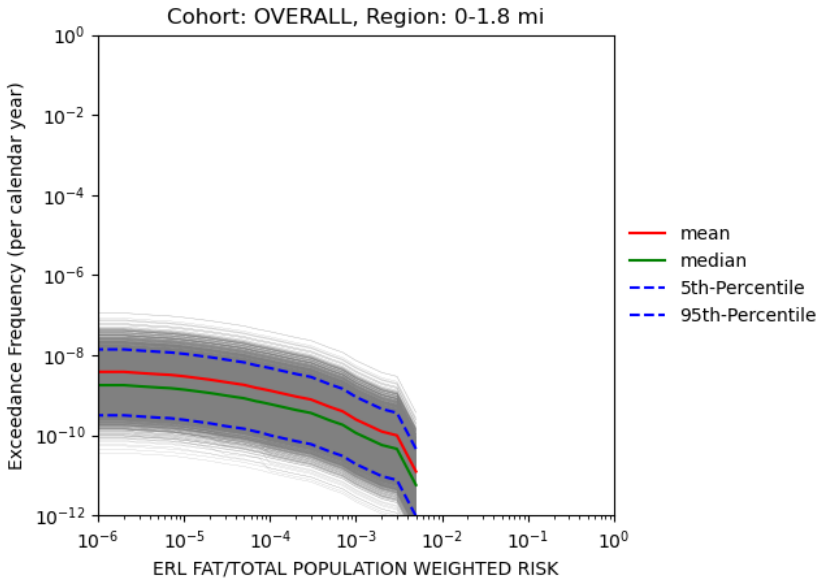


Figure 5-3 CCDF Curves of Uncertain Population-Weighted Individual Early Fatality Risk Within 1 Mile of the Site Boundary

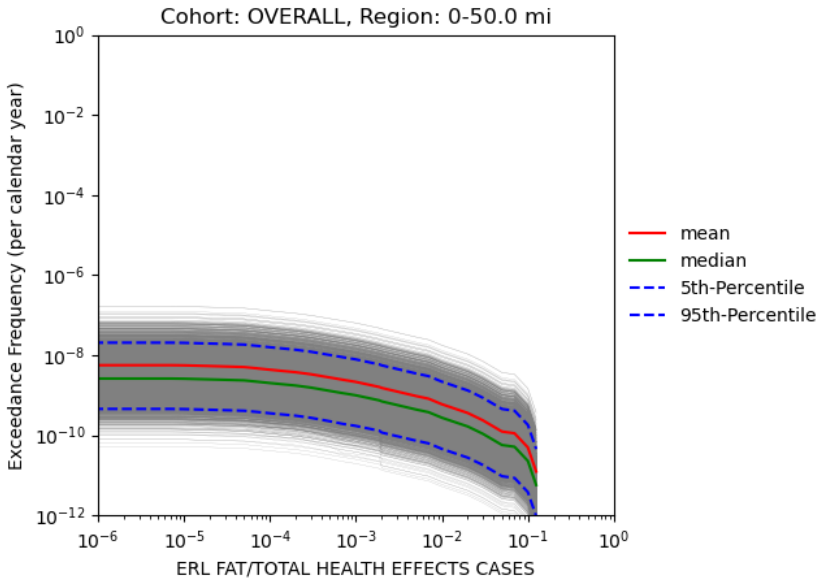


Figure 5-4 CCDF Curves of Uncertain Total Early Fatalities within 50 Miles

CCDF curves are presented because they are consistent with PRA state-of-practice and were used in the NUREG-1150 summary report. Table 5-6 summarizes the mean exceedance frequencies and the 90 percent probability intervals for the frequencies of exceeding specified levels of population-weighted early fatality risk within 1 mile of the site boundary. Table 5-7 shows similar information for the frequencies of exceeding specified levels of total early fatality risk within 50 miles of the plant.

Table 5-6 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Levels of Population-Weighted Early Fatality Risk (0–1.8 Miles)

Population-Weighted Early Fatality Risk (0–1.8 miles)	Mean Exceedance Frequency (/yr)	Exceedance Frequency 90% Probability Interval (/yr)
10^{-6}	3.8E-09	3.2E-10 – 1.4E-08
10^{-5}	3.0E-09	2.4E-10 – 1.1E-08
10^{-4}	1.3E-09	1.0E-10 – 4.8E-09

[1] No realizations resulted in an individual early fatality risk of 10^{-4}.

Table 5-7 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Levels of Total Early Fatality Risk (0–50 Miles)

Total Early Fatality Risk (0–50 miles)	Mean Exceedance Frequency (/yr)	Exceedance Frequency 90% Probability Interval (/yr)
10^{-6}	5.6E-09	4.6E-10 – 2.1E-08
10^{-5}	5.6E-09	4.5E-10 – 2.0E-08
10^{-4}	4.3E-09	3.6E-10 – 1.6E-08
10^{-3}	2.2E-09	1.7E-10 – 7.9E-09

Note that Figure 5-4 shows that the maximum number of early fatalities observed across all modeled accident scenarios and across all weather trials was essentially less than one fatality. Although it seems counterintuitive to have a non-integer result for the total number of early fatalities that is less than one, this result occurs because of two features of the MACCS code that affect modeling of the population surrounding a nuclear power plant site: (1) the assignment of populations to discrete spatial grid elements can cause a fraction of an individual to be assigned to a specific grid element, and (2) population fractions are assigned to each of the modeled emergency-response cohorts, which means a non-integer number can be assigned to each cohort. For these reasons, it is possible for an accident scenario to result in more than zero but less than one early fatality.

From Figure 5-4, we can estimate that the mean frequency of exceeding one early fatality within 50 miles of the reference nuclear power plant site is less (potentially much less) than 1×10^{-10} per calendar-year. Put another way, accidents that result in at least one early fatality are expected to occur no more frequently than about once every 10 billion years, further indicating that the early fatality risk to the population surrounding the reference nuclear power plant site is extremely low. The staff recognizes the inherent uncertainty in these very low numbers; however, the conclusion remains that the probability of an early fatality is very small.

5.2.2 Significant Contributors to Risk

As discussed in Section 4.2, early fatality risks (which are very low) arise only from the SD-COPEN-RCSVENT and SD-COPEN-HEADOFF release categories, with virtually the entire contribution (99.9 percent) coming from SD-COPEN-RCSVENT. These release categories involve an open containment hatch and/or personnel airlock, with operator failure to reclose them, and the release is considered to reach the environment directly via these large openings. For SD-COPEN-RCSVENT, prior to any breach of the reactor vessel lower head by core debris, the RCS is vented or has a persistent leak not including normally cycling relief valves (e.g., pipe break or manual bleed), such that retention of aerosols inside the RCS may be intermediate in magnitude. For SD-COPEN-HEADOFF, the plant is in an operating state at the time of the accident where the reactor vessel head has been removed, so in-vessel release from the core benefits from little to no retention inside the RCS.

The basic events in the integrated Level 1 and Level 2 PRA logic models that have a composite FV importance greater than 0.005 for mean annual population-weighted individual early fatality risk within 1 mile of the site boundary and for mean annual risk of total early fatalities within 50 miles, for the reactor at-shutdown, are essentially the same for both offsite public risk metrics related to early health effects. Review of the composite FV importance rankings reveals that, for the reactor at-shutdown, LOOP is the initiating event contributing by far the most to both early fatality risk and mean annual risk of total early fatalities within 50 miles (approximately 90 percent). Loss of inventory initiating events collectively contribute an additional 8 percent. Also, approximately 93 percent of early fatality risk occurs in just two POSs, draining the RCS to mid-loop prior to refueling (56 percent) or after refueling (37 percent).

Aside from the boundary condition basic events (i.e., related to plant operating type and state) and initiating events, the top two contributors to both early fatality risk measures are (1) operator failure to establish low pressure gravity feed given a LOOP (approximately 83 percent) and (2) operator failure to close the equipment hatch with lowered RCS inventory and no AC power (approximately 81 percent). As is evident by their contribution percentages, these two operator errors usually occur together in the same cutsets.

Other significant contributors to early fatality risk include equipment failures or operator errors that lead to a station blackout. Included in this set of basic events are common-cause failures of the RAT input breakers (contributing 33 percent) and the load sequencers (contributing 20 percent), as well as random failures of these components and the diesel generators, and operator failure to recover offsite power.

5.3 Latent Health Effects

The following discussion is abridged from Section 5.5 of NRC (2022a) and revised to discuss the risks from events initiated during LPSD operations. Three offsite public risk metrics pertaining to latent health effects are calculated and reported. As discussed in Section 3.6 of NRC (2022a), these results assume a linear no-threshold model for latent health effects. The population-weighted latent cancer fatality risk (0–10 miles) obtained from the MACCS Type 8 output reports the average annual risk to individuals within 10 miles of dying from cancers caused by doses arising from modeled accidental releases of radiological materials from the reference nuclear power plant site. This result, by weighting health effects cases across the entire 10–mile population, reflects the occurrence of exposures relative to the distribution of population around the site. Results for this metric can be compared to the average individual

latent cancer fatality risk QHO to obtain insights related to the NRC's safety goal policy (NRC, 1986). Total latent cancer fatality risk (0–50 miles, 0–100 miles) obtained from the MACCS Type 1 output measures the total annual risk to society of cancer deaths among the population within 50 miles and 100 miles caused by excess lifetime exposure to radiation due to modeled accidental releases of radiological materials from the reference nuclear power plant site.

As shown in Table 4-3, reproduced in Table 5-8, the frequency-weighted mean annual population-weighted individual latent fatality risk within 10 miles of the site boundary is 4.5×10^{-9} per calendar-year. The frequency-weighted mean annual risk of total latent fatalities within 50 miles is 1.8×10^{-3} latent fatalities per calendar-year, and the frequency-weighted mean annual risk of total latent fatalities within 100 miles is 4.6×10^{-3} latent fatalities per calendar-year. These values were obtained by weighting the conditional mean (over all weather trials) consequence values for individual release categories by the point estimate of the individual release category frequencies. Also shown for comparison in Table 5-8 are the summary latent fatality risk measures from at-power scenarios, adapted from Table 5-16 of NRC (2023).

Table 5-8 Summary of Latent Fatality Risk Measures

Scope Piece	Release Freq. (/yr)	Individual Latent Fatality Risk, 0–10 mi (/yr)[1]	Total Latent Fatality Risk, 0–50 mi (persons/yr)[1]	Total Latent Fatality Risk, 0–100 mi (persons/yr)[1]
LPSD (Internal events)	1.2E-05	4.5E-09	1.8E-03	4.6E-03
At-Power (Internal events and internal floods)	6.4E-05[2]	2.3E-08	4.8E-03	1.0E-02
At-Power (All hazards[3])	1.6E-04[2]	6.0E-08	1.3E-02	2.7E-02

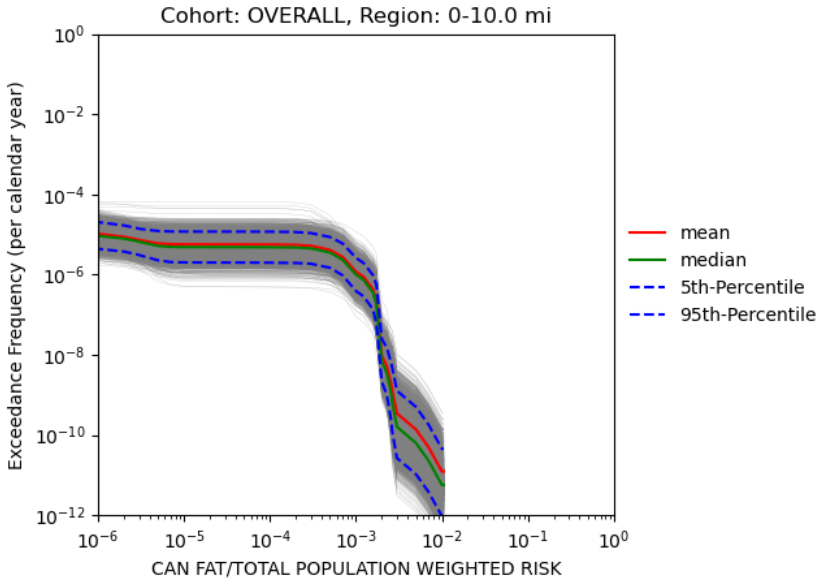
[1] *Results are a frequency-weighted sum of all release categories. Reactor at-power results are based on reactor-years. To convert the risk metric of the **reactor at-power** from per reactor-year to per calendar-year, multiply the result by the plant availability factor of 0.93. Note, the resulting reactor, at-power, calendar-year risk does not include the risk associated with reactor shutdown operations during the calendar year.*

[2] *Frequency of reactor at-power events are given in reactor-years. To convert the release frequency of the **reactor at-power** from per reactor-year to per calendar-year, multiply the frequency by the plant availability factor of 0.93. Note, the resulting reactor, at-power, calendar-year release frequency does not include the contribution from reactor shutdown operations during the calendar year.*

[3] *Includes at-power internal events, internal floods, internal fires, seismic events, and high-wind events.*

5.3.1 CCDF Curves and Summary Tables of Exceedance Frequencies

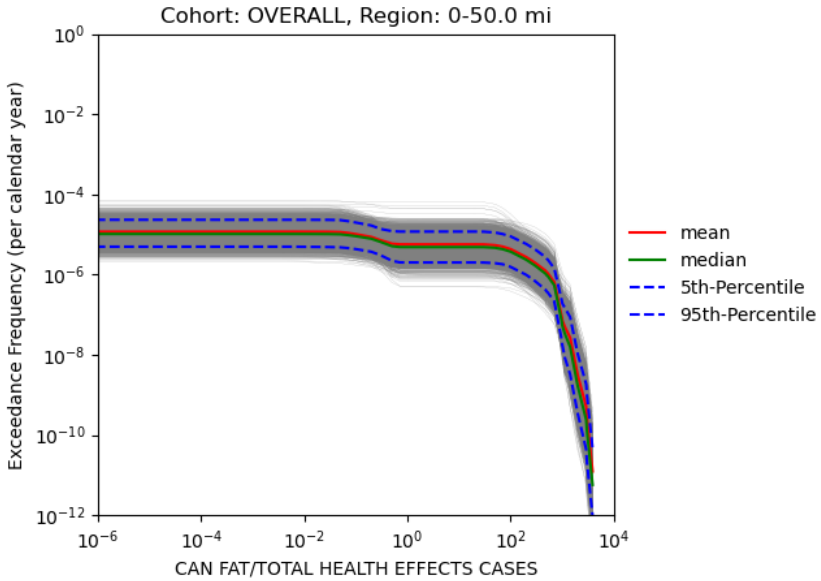
Figure 5-5 displays sets of CCDF curves that illustrate the frequencies of exceeding specified levels of individual latent fatality risk for the population within 10 miles of the reference nuclear power plant site. Examination of the data that supports Figure 5-5 shows that most modeled core damage frequency arises from events resulting in an individual latent fatality risk less than 5×10^{-6}. The modeled frequency of conditional risks greater than 3×10^{-4} are increasingly unlikely. The risk drops precipitously at values greater than 1×10^{-3} and reach a maximum value of 1×10^{-2} at a frequency of less than 1×10^{-11} per reactor year.



Note: CAN FAT/TOTAL: Total (across all cancer sites) latent fatality risk

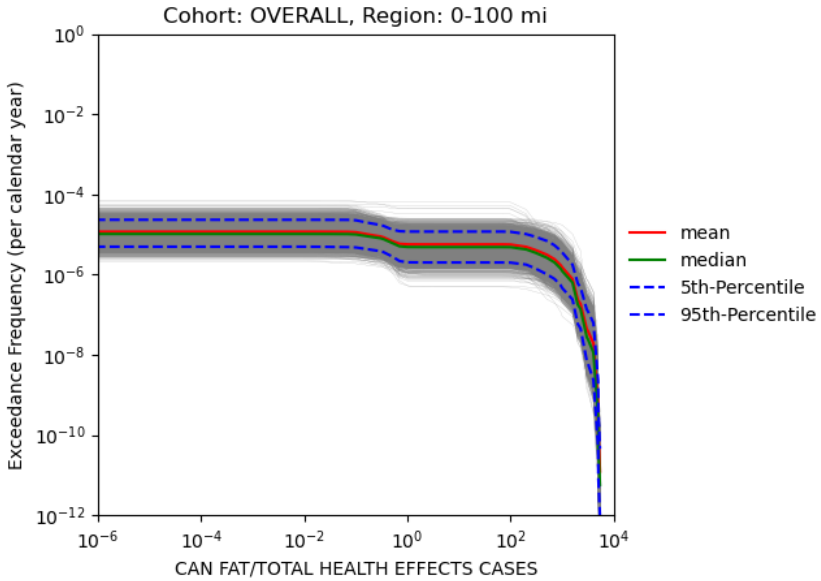
Figure 5-5 CCDF Curves of Uncertain Individual Latent Fatality Risk within 10 Miles

Figure 5-6 and Figure 5-7 display sets of CCDF curves that illustrate the frequencies of exceeding specified levels of latent fatalities within 50 miles and 100 miles of the reference nuclear power plant site, respectively. As shown in Figure 5-6 and Figure 5-7, most of the modeled core damage frequency arises from events with less than one projected latent fatality. The slopes of the CCDF curves appear to become more negative at about 100 fatalities (within 50 miles) and 300 fatalities (within 100 miles), and the frequency of exceeding 1000 fatalities (within 50 miles) and 3000 fatalities (within 100 miles) drops precipitously. This indicates that the occurrence of more than 1000 total latent fatalities is very unlikely. Examination of Figure 5-6 and Figure 5-7 and their underlying data reveals that the number of latent fatalities reaches a maximum value of approximately 3000 (within 50 miles) and 5000 (within 100 miles) at a frequency of less than 1×10^{-10} per calendar-year.



Note: CAN FAT/TOTAL: Total (across all cancer sites) latent fatalities

Figure 5-6 CCDF Curves of Uncertain Total Latent Fatality Cases within the 0–50-Mile Interval



Note: CAN FAT/TOTAL: Total (across all cancer sites) latent fatalities

Figure 5-7 CCDF Curves of Uncertain Total Latent Fatality Cases within the 0–100-Mile Interval

CCDF curves are presented because they are consistent with PRA state-of-practice and were used in the NUREG-1150 summary report. Table 5-9 summarizes the mean exceedance frequencies and the 90 percent probability intervals for the frequencies of exceeding specified

levels of population-weighted latent cancer fatality risk within 10 miles. Table 5-10 and Table 5-11 summarize the mean exceedance frequencies and the 90 percent probability intervals for the frequencies of exceeding specified numbers of latent cancer fatalities within 50 miles and 100 miles, respectively.

Table 5-9 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Levels of Population-Weighted Latent Cancer Fatality Risk (0–10 Miles)

Population-Weighted Latent Cancer Fatality Risk (0–10 miles)	Mean Exceedance Frequency (/yr)	Exceedance Frequency 90% Probability Interval (/yr)
$1x10^{-6}$	1.0E-05	4.4E-06 – 2.0E-05
$1x10^{-5}$	5.7E-06	2.0E-06 – 1.2E-05
$1x10^{-4}$	5.6E-06	2.0E-06 – 1.2E-05
$1x10^{-3}$	1.2E-06	3.9E-07 – 2.6E-06

Table 5-10 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Numbers of Latent Cancer Fatalities (0–50 Miles)

Latent Cancer Fatalities (0–50 miles)	Mean Exceedance Frequency (/yr)	Exceedance Frequency 90% Probability Interval (/yr)
1	5.7E-06	2.0E-06 – 1.2E-05
10	5.7E-06	2.0E-06 – 1.2E-05
100	4.3E-06	1.6E-06 – 9.0E-06
1000	7.2E-08	1.8E-08 – 1.9E-07

Table 5-11 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Numbers of Latent Cancer Fatalities (0–100 Miles)

Latent Cancer Fatalities (0–100 miles)	Mean Exceedance Frequency (/yr)	Exceedance Frequency 90% Probability Interval (/yr)
1	5.7E-06	2.0E-06 – 1.2E-05
10	5.7E-06	2.0E-06 – 1.2E-05
100	5.6E-06	2.0E-06 – 1.2E-05
1000	1.5E-06	4.6E-07 – 3.6E-06

5.3.2 Significant Contributors to Risk

Figure 4-19 and Figure 4-20 illustrate the relative contributions of each modeled radiological release category to the mean annual risk of total latent cancer fatalities within 50 miles and 100 miles, respectively. These figures show that, similar to the results for population dose, the two release categories that make the largest contribution to mean annual risk of total latent cancer fatalities within both 50 and 100 miles are: (1) a release category in which the containment fails due to overpressure by steam sometime in between the start of the accident and the start of

core damage (SD-CF-Before-CD) and (2) a release category in which the release to the environment occurs via a containment penetration that fails to be isolated by manual action or via a pre-existing leakage path (not including open containment hatch or personnel airlock) (SD-CIF). These two radiological release categories collectively contribute around 70 percent of the mean annual risk of total latent cancer fatalities within both 50 and 100 miles. Taken together, the three release categories that involve an open containment hatch and/or personnel airlock, with operator failure to reclose them (SD-COPEN-HEADOFF, SD-COPEN-RCSINTACT, SD-COPEN-RCSVENT), collectively contribute an additional 16 percent (within 50 miles) to 21 percent (within 100 miles) of the mean annual risk of total latent cancer fatalities. The release category in which the containment fails hours after vessel breach due to a global deflagration or detonation (SD-ICF-BURN) makes up the bulk of the remaining contribution (9–11 percent).

As shown in Figure 4-25, the same six release categories discussed above also dominate mean annual population-weighted individual latent cancer fatality risk within 10 miles. However, for this risk metric, the order is reversed for SD-ICF-BURN (18 percent) and the set of open containment release categories (12 percent).

The basic events in the integrated Level 1 and Level 2 PRA logic models that have a composite FV importance greater than 0.005 for mean annual population-weighted individual latent cancer fatality risk within 10 miles and mean annual risk of total latent cancer fatalities within both 50 miles and 100 miles, for the reactor at-shutdown, are virtually the same for both risk metrics. Review of the composite FV importance rankings reveals that, for the reactor at-shutdown, LOOP is the initiating event contributing by far the most to mean annual population-weighted individual latent cancer fatality risk within 10 miles and mean annual risk of total latent cancer fatalities within both 50 and 100 miles (73–79 percent). Other initiating event contributors with the reactor at-shutdown (all in the 4–5 percent range) include (1) loss of NSCW, (2) an overdraining event with the reactor in mid-loop operation, (3) loss of RHR, and (4) loss of a 4,160 V AC bus. Also, approximately 80 percent of mean annual population-weighted individual latent cancer fatality risk within 10 miles and mean annual risk of total latent cancer fatalities within both 50 and 100 miles occurs in just two POSs, refueling operation (60–65 percent) or when the pressurizer is water solid for hydrogen degassing prior to refueling (15–17 percent).

Aside from the boundary condition basic events (i.e., related to plant operating type and state) and initiating events, most of the highest contributing events involve various human errors (e.g., failures to restore electric power, failure to establish low-pressure gravity feed given LOOP, or failure to isolate small containment penetrations [with high dependency on a previous operator failure]). Other high contributing events include failures leading to a station blackout (e.g., failures of diesel generators, RAT input breakers, or load sequencers) and events associated with combustion (detonations or deflagrations) within containment. Note, as mentioned previously, some combustion events result in direct failure of the containment, while others occur early in the accident progression before there is sufficient combustible gas to result in containment failure. In these latter cases, the early combustible events can reduce the amount of combustible gas in containment, thereby reducing the likelihood of a larger combustible event later in the accident progression. However, the most important factor influencing late combustion-induced containment failure is the success of late containment heat removal resulting in reduced steam concentrations. This action influences the likelihood of combustion events in the late timeframe to a greater extent than whether there were earlier combustion events.

5.4 Land Contamination

The following discussion is abridged from Section 5.6 of NRC (2022a) and revised to discuss the risks from events initiated during LPSD operations. Using the MACCS Type D output, land contamination risk is calculated and reported over two spatial intervals around the reference nuclear power plant: (1) 0–50 miles, and (2) 0–100 miles. A Cs-137 concentration level of 555 kBq/m^2 (15 Ci/km^2) was selected for calculation and reporting because it is likely to require some level of restriction during the intermediate and recovery phases. As discussed in NRC (2022a), metrics that measure land contamination risk were selected for three main reasons: (1) NRC's mission is to protect people and the environment; (2) land can have inherent value to people, regardless of whether it is populated or it supports economic activity; and (3) risk metrics that measure economic costs and affected population may not capture risks to land areas around the reference nuclear power plant site that are not populated nor used for economic activity.

As shown in Table 4-4, reproduced in Table 5-12, the frequency-weighted mean annual land contamination risk within 50 miles is 5.8×10^{-3} square miles per calendar-year, and the frequency-weighted mean annual land contamination risk within 100 miles is 8.7×10^{-3} square miles per calendar-year. These values were obtained by weighting the conditional mean (over all weather trials) consequence values for individual release categories by the point estimate of the individual release category frequencies. Also shown for comparison in Table 5-12 are the summary land contamination risk measures from at-power scenarios, adapted from Table 5-26 of NRC (2023). It may be noted that the land contamination risk from LPSD internal event scenarios is comparable to the land contamination risk from the reactor, at-power, internal event and internal flood scenarios and is approximately half of the risk from at-power scenarios for all hazards combined. This is consistent with the mean cesium releases expected from the LPSD release categories. The mean frequency-weighted cesium release from all release categories for LPSD internal events is approximately 19 Ci/yr (see Figure 3-1), whereas the mean frequency-weighted cesium release from the release categories for the reactor, at-power, internal events and internal floods is approximately 13 Ci/yr and the mean frequency-weighted cesium release from the release categories for the reactor, at-power, all hazards combined is approximately 35 Ci/yr.

Table 5-12 Summary of Land Contamination (MACCS Type D) Risk Measures

Scope Piece	Release Freq. (/yr)	Total Land Contamination Risk (mi^2/yr), 0–50 miles[1]	Total Land Contamination Risk (mi^2/yr), 0–100 miles[1]
LPSD (Internal events)	1.2E-05	5.8E-03	8.7E-03
At-Power (Internal events and internal floods)	6.4E-05[2]	4.2E-03	4.6E-03
At-Power (All hazards[3])	1.6E-04[2]	1.2E-02	1.2E-02

[1] *Results are a frequency-weighted sum of all release categories. Reactor at-power results are based on reactor-years. To convert the risk metric of the **reactor at-power** from per reactor-year to per calendar-year, multiply the result by the plant availability factor of 0.93. Note, the resulting reactor, at-power, calendar-year risk does not include the risk associated with reactor shutdown operations during the calendar year.*

[2] *Frequency of reactor at-power events are given in reactor-years. To convert the release frequency of the **reactor at-power** from per reactor-year to per calendar-year, multiply the frequency by the plant availability factor of 0.93. Note, the resulting reactor, at-power, calendar-year release frequency does not include the contribution from reactor shutdown operations during the calendar year.*

[3] *Includes at-power internal events, internal floods, internal fires, seismic events, and high-wind events.*

5.4.1 CCDF Curves and Summary Tables of Exceedance Frequencies

Figure 5-8 and Figure 5-9 display sets of CCDF curves that illustrate the frequencies of exceeding specified levels of land area (mi^2) exceeding a deposition of 555 kBq/m^2 (15 Ci/km^2) within 50 miles and 100 miles of the reference nuclear power plant site, respectively. As shown in Figure 5-8 and Figure 5-9, most of the modeled core damage frequency is associated with events resulting in less than 1 square mile of land contamination. The slopes of the CCDF curves appear to become more negative at about 1000 mi^2. Although there is some increase in the affected land area as the region of interest extends beyond 50 miles, affected land areas of greater than 1,000 mi^2 are increasingly unlikely, while the frequency of affected land areas of greater than 2,000–3,000 mi^2 is vanishingly small. Examination of Figure 5-8 and Figure 5-9 and their underlying data reveals that the maximum (at a frequency of less than 5×10^{-10} per calendar-year) affected land area across all modeled accident scenarios and all weather trials is about 7,000 mi^2 for the 0–50-mile region and about 20,000 mi^2 for the 0–100-mile region.

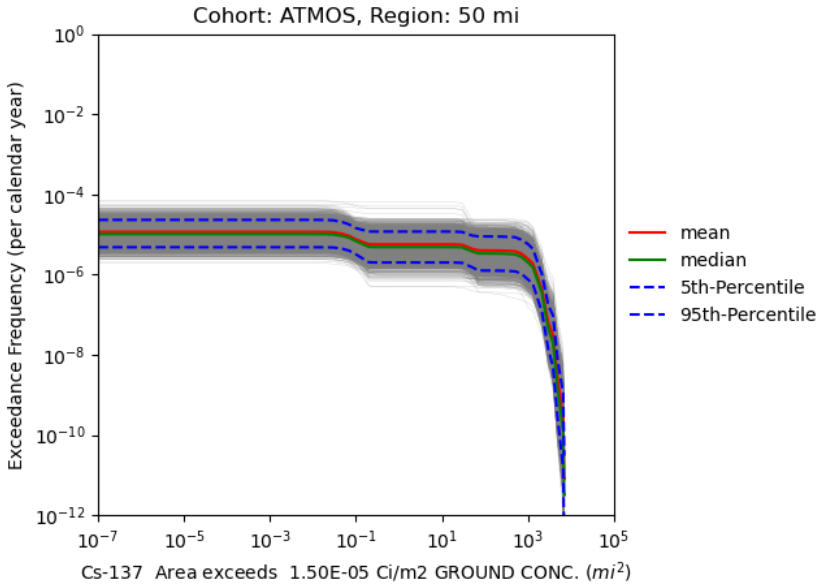


Figure 5-8 CCDF Curves for Uncertain Land Area (mi²) Exceeding a Deposition of 555 kBq/m² (15 Ci/km²) within the 0–50-Mile Interval

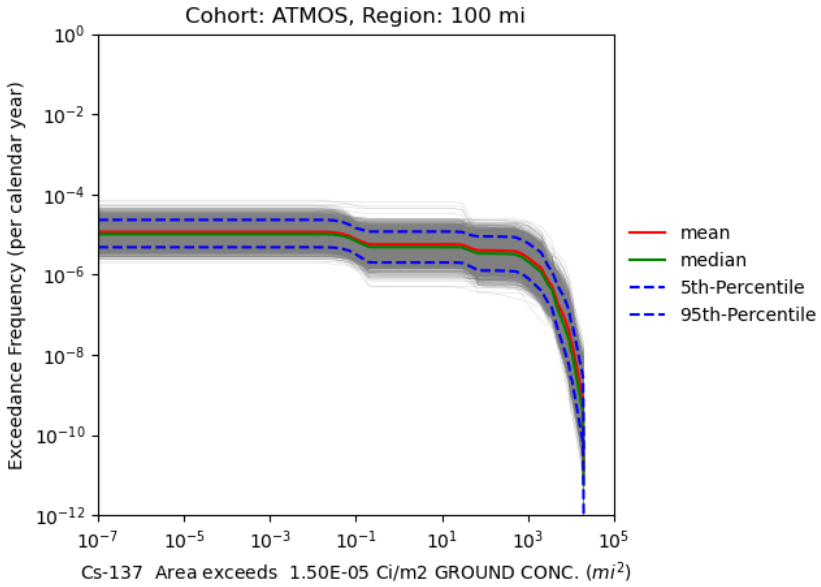


Figure 5-9 CCDF Curves for Uncertain Land Area (mi²) Exceeding a Deposition of 555 kBq/m² (15 Ci/km²) within the 0–100-Mile Interval

CCDF curves are presented because they are consistent with PRA state-of-practice and were used in the NUREG-1150 summary report. Table 5-13 and Table 5-14 summarize the mean exceedance frequencies and the 90 percent probability intervals for the frequencies of exceeding land areas within 50 miles and 100 miles, respectively, that exceed a Cs-137 concentration of 555 kBq/m^2 (15 Ci/km^2).

Table 5-13 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Levels of Land Area Exceeding Cs-137 Concentration of 555 kBq/m^2 (15 Ci/km^2) (0–50 Miles)

Land Area (mi^2) Exceeding Cs-137 Concentration of 555 kBq/m^2 (15 Ci/km^2) (0–50 miles)	Mean Exceedance Frequency (/yr)	Exceedance Frequency 90% Probability Interval (/yr)
1	5.7E-06	2.0E-06 – 1.2E-05
10	5.7E-06	2.0E-06 – 1.2E-05
100	4.0E-06	1.3E-06 – 9.0E-06
1000	2.5E-06	7.6E-07 – 5.8E-06

Table 5-14 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Levels of Land Area Exceeding Cs-137 Concentration of 555 kBq/m^2 (15 Ci/km^2) (0–100 Miles)

Land Area (mi^2) Exceeding Cs-137 Concentration of 555 kBq/m^2 (15 Ci/km^2) (0–100 miles)	Mean Exceedance Frequency (/yr)	Exceedance Frequency 90% Probability Interval (/yr)
1	5.7E-06	2.0E-06 – 1.2E-05
10	5.7E-06	2.0E-06 – 1.2E-05
100	4.0E-06	1.3E-06 – 9.0E-06
1000	2.7E-06	8.2E-07 – 6.1E-06

5.4.2 Significant Contributors to Risk

Figure 4-31 and Figure 4-32 illustrate the relative contributions of each modeled radiological release category to the mean annual risk of land area exceeding a Cs-137 concentration of 555 kBq/m^2 (15 Ci/km^2) within 50 miles and 100 miles, respectively. These figures show that the two release categories that make the largest contribution to mean annual risk of land area exceeding a Cs-137 concentration of 555 kBq/m^2 (15 Ci/km^2) within both 50 and 100 miles are: (1) a release category in which the containment fails due to overpressure by steam sometime in between the start of the accident and the start of core damage (SD-CF-Before-CD) and (2) a release category in which the release to the environment occurs via a containment penetration that fails to be isolated by manual action or via a pre-existing leakage path (not including open containment hatch or personnel airlock) (SD-CIF). These two radiological release categories collectively contribute 81 percent of the mean annual risk of land area exceeding a Cs-137 concentration of 555 kBq/m^2 (15 Ci/km^2) within 50 miles and 72 percent of the risk within 100 miles. Taken together, the three release categories that involve an open containment hatch

and/or personnel airlock, with operator failure to reclose them (SD-COPEN-HEADOFF, SD-COPEN-RCSINTACT, SD-COPEN-RCSVENT), collectively contribute an additional 17 percent (within 50 miles) to 27 percent (within 100 miles) of the mean annual risk of land contamination.

The basic events in the integrated Level 1 and Level 2 PRA logic models that have a composite FV importance greater than 0.005 for mean annual risk of land area exceeding a Cs-137 concentration of 555 kBq/m^2 (15 Ci/km^2) within both 50 and 100 miles, for the reactor at-shutdown, are mostly in common for both risk metrics. Review of the composite FV importance rankings reveals that, for the reactor at-shutdown, LOOP is the initiating event contributing by far the most to mean annual risk of land area exceeding a Cs-137 concentration of 555 kBq/m^2 (15 Ci/km^2) within both 50 and 100 miles (over 80 percent). Other initiating event contributors with the reactor at-shutdown (all in the 4–5 percent range) include (1) loss of NSCW, (2) loss of a 4,160 V AC bus, and (3) loss of RHR. Also, well over 80 percent of mean annual risk of land area exceeding a Cs-137 concentration of 555 kBq/m^2 (15 Ci/km^2) within both 50 and 100 miles occurs in just two POSs, refueling operation (72–76 percent) or when the pressurizer is water solid for hydrogen degassing prior to refueling (12–13 percent).

Aside from the boundary condition basic events (i.e., related to plant operating type and state) and initiating events, most of the highest contributing events involve various human errors (e.g., failures to restore electric power, failure to establish low-pressure gravity feed given LOOP, or failure to isolate small containment penetrations [with high dependency on a previous operator failure]). Other high contributing events include failures leading to a station blackout (e.g., failures of diesel generators, RAT input breakers, or load sequencers).

5.5 Affected Population

The following discussion is abridged from Section 5.7 of NRC (2022a) and revised to discuss the risks from events initiated during LPSD operations. Two offsite public risk metrics pertaining to affected population are calculated and reported. Using the MACCS Type 14 output, the risk of total population affected by intermediate-phase relocation is reported over two spatial intervals around the reference nuclear power plant: (1) 0–50 miles, and (2) 0–100 miles. This metric is used to quantify the total annual risk to society of the population within 50 miles and 100 miles being relocated in the intermediate phase to avert radiological dose due to modeled accidental releases of radiological materials from the reference nuclear power plant site. As discussed in NRC (2022a), metrics that quantify the population affected by intermediate-phase relocation were selected to serve as a surrogate metric for the adverse public health and safety consequences associated with implementing protective actions to avert population dose. Inclusion of these indirect metrics enables a more complete characterization of the adverse offsite consequences attributable to a spectrum of accidental releases from the reference nuclear power plant site by illuminating tradeoffs between radiological and non-radiological health and safety risks.

As shown in Table 4-4, as reproduced in Table 5-15, the frequency-weighted mean annual population relocation risk within 50 miles is 0.32 persons per calendar-year and the frequency-weighted mean annual population relocation risk within 100 miles is 0.46 persons per calendar-year. These values were obtained by weighting the conditional mean (over all weather trials) consequence values for individual release categories by the point estimate of the individual release category frequencies. Also shown for comparison in Table 5-15 are the summary affected population risk measures from at-power scenarios, adapted from Table 5-33 of

NRC (2023). It may be noted that the affected population risk from LPSD internal event scenarios is comparable to the affected population risk from reactor, at-power, internal event and internal flood scenarios and is less than one-third of the reactor, at-power risk from all hazards combined.

Table 5-15 Summary of Affected Population Risk Measures

Scope Piece	Release Freq. (/yr)	Intermediate Phase Relocation Risk (persons/yr), 0–50 miles[1]	Intermediate Phase Relocation Risk (persons/yr), 0–100 miles[1]
LPSD (Internal events)	1.2E-05	0.32	0.46
At-Power (Internal events and internal floods)	6.4E-05[2]	0.47	0.49
At-Power (All hazards[3])	1.6E-04[2]	1.4	1.5

[1] *Results are a frequency-weighted sum of all release categories. Reactor at-power results are based on reactor-years. To convert the risk metric of the **reactor at-power** from per reactor-year to per calendar-year, multiply the result by the plant availability factor of 0.93. Note, the resulting reactor, at-power, calendar-year risk does not include the risk associated with reactor shutdown operations during the calendar year.*

[2] *Frequency of reactor at-power events are given in reactor-years. To convert the release frequency of the **reactor at-power** from per reactor-year to per calendar-year, multiply the frequency by the plant availability factor of 0.93. Note, the resulting reactor, at-power, calendar-year release frequency does not include the contribution from reactor shutdown operations during the calendar year.*

[3] *Includes at-power internal events, internal floods, internal fires, seismic events, and high-wind events.*

5.5.1 CCDF Curves and Summary Tables of Exceedance Frequencies

Figure 5-10 and Figure 5-11 display sets of CCDF curves that illustrate the frequencies of exceeding specified levels of intermediate phase relocation population sizes within 50 miles and 100 miles of the reference nuclear power plant site, respectively. As shown in Figure 5-10 and Figure 5-11, most of the modeled core damage frequency arises from events that are projected to result in intermediate phase relocation populations of less than 10,000 persons. The slopes of the CCDF curves appear to become more negative at an affected population of slightly less than 10,000 persons. Affected populations of greater than 100,000 persons are increasingly unlikely. Examination of Figure 5-10 and Figure 5-11 and their underlying data reveal that (at a frequency of 5×10^{-10} per calendar-year or less) the maximum affected population across all modeled accident scenarios and all-weather trials is 700,000 (within 50 miles) and 2 million (within 100 miles).

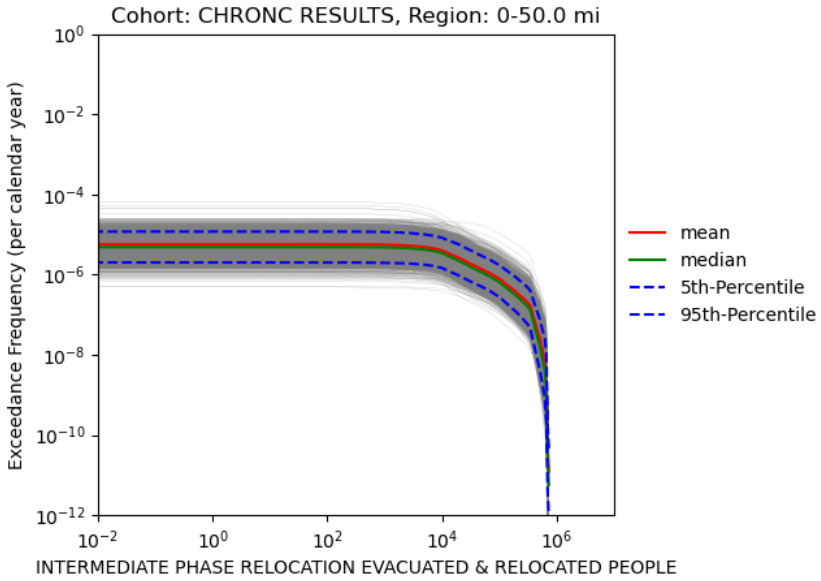


Figure 5-10 CCDF Curves of Uncertain Intermediate Phase Relocation Population within the 0–50-Mile Interval

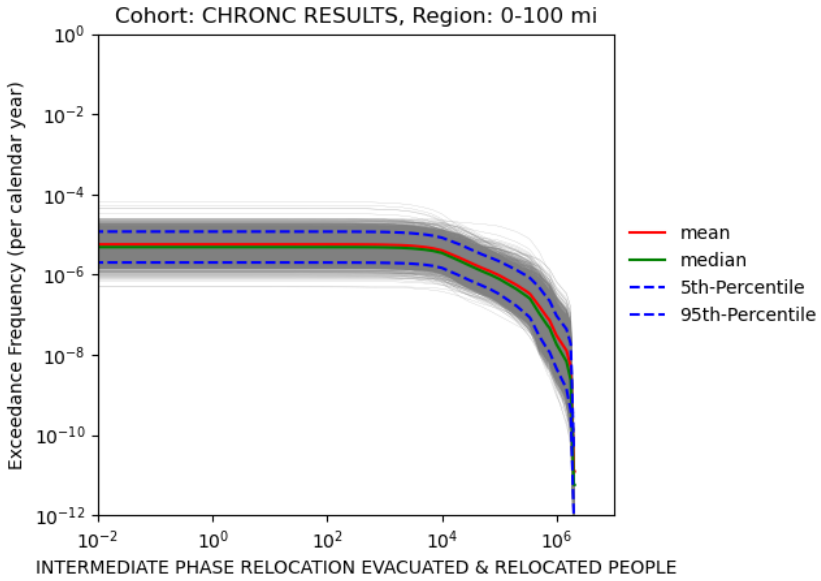


Figure 5-11 CCDF Curves of Uncertain Intermediate Phase Relocation Population within the 0–100-Mile Interval

CCDF curves are presented because they are consistent with PRA state-of-practice and were used in the NUREG-1150 summary report. Table 5-16 and Table 5-17 summarize the mean exceedance frequencies and the 90 percent probability intervals for the frequencies of exceeding specified numbers of people affected by intermediate-phase relocation within 50 miles and 100 miles, respectively.

Table 5-16 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Numbers of People Affected By Intermediate-Phase Relocation (0–50 Miles)

Number of People Affected by Intermediate-Phase Relocation (0–50 miles)	Mean Exceedance Frequency (/yr)	Exceedance Frequency 90% Probability Interval (/yr)
1,000	5.6E-06	2.0E-06 – 1.2E-05
10,000	4.0E-06	1.5E-06 – 8.3E-06
100,000	7.9E-07	2.8E-07 – 1.7E-06

Table 5-17 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Numbers of People Affected By Intermediate-Phase Relocation (0–100 Miles)

Number of People Affected by Intermediate-Phase Relocation (0–100 miles)	Mean Exceedance Frequency (/yr)	Exceedance Frequency 90% Probability Interval (/yr)
1,000	5.6E-06	2.0E-06 – 1.2E-05
10,000	4.0E-06	1.5E-06 – 8.4E-06
100,000	9.6E-07	3.3E-07 – 2.2E-06

5.5.2 Significant Contributors to Risk

Figure 4-42 and Figure 4-43 illustrate the relative contributions of each modeled radiological release category to the mean annual risk of population affected by intermediate-phase relocation within 50 miles and 100 miles, respectively. These figures show that the release category that makes the largest contribution to mean annual risk of population affected by intermediate-phase relocation within both 50 and 100 miles is a release category in which the containment fails due to overpressure by steam sometime in between the start of the accident and the start of core damage (SD-CF-Before-CD). This release category contributes 48 percent and 36 percent of the mean annual risk of population affected by intermediate-phase relocation within 50 and 100 miles, respectively. Taken together, the three release categories that involve an open containment hatch and/or personnel airlock, with operator failure to reclose them (SD-COPEN-HEADOFF, SD-COPEN-RCSINTACT, SD-COPEN-RCSVENT), collectively contribute an additional 31 percent (within 50 miles) to 49 percent (within 100 miles) of the mean annual risk of population affected by intermediate-phase relocation.

The basic events in the integrated Level 1 and Level 2 PRA logic models that have a composite FV importance greater than 0.005 for mean annual risk of population affected by intermediate-phase relocation within both 50 and 100 miles, for the reactor at-shutdown, are virtually the

same for both risk metrics. Review of the composite FV importance rankings reveals that, for the reactor at-shutdown, LOOP is the initiating event contributing by far the most to mean annual risk of population affected by intermediate-phase relocation within both 50 miles (79 percent) and 100 miles (83 percent). Other initiating event contributors with the reactor at-shutdown (all in the 3–5 percent range) include (1) loss of NSCW, (2) loss of RHR, (3) loss of a 4,160 V AC bus, and (4) overdraining during mid-loop before refueling. Also, the POSs with the largest contribution to mean annual risk of population affected by intermediate-phase relocation within both 50 and 100 miles are refueling operation (49–60 percent) or when the pressurizer is water solid for hydrogen degassing prior to refueling (15–17 percent).

Aside from the boundary condition basic events (i.e., related to plant operating type and state) and initiating events, most of the highest contributing events involve various human errors (e.g., failures to restore electric power, failure to establish low-pressure gravity feed given LOOP, or failure of emergency closure of the equipment hatch with no AC power available). Other high contributing events include failures leading to a station blackout (e.g., failures of diesel generators, RAT input breakers, or load sequencers).

5.6 Economic Costs

The following discussion is abridged from Section 5.8 of NRC (2022a) and revised to discuss the risks from events initiated during LPSD operations. Using the MACCS Type 10 output, the economic costs risk is reported over two spatial intervals around the reference nuclear power plant: (1) 0–50 miles, and (2) 0–100 miles. The risk of total economic costs measures the total annual risk to society of economic costs from implementation of protective actions to avert radiological dose within 50 miles and 100 miles due to modeled accidental releases of radiological materials from the reference nuclear power plant site. As discussed in NRC (2022a), economic cost risk provides a measure of the offsite property damage risk attributed to potential accidental releases from nuclear facilities. Like population dose, this metric is typically estimated over the 0–50-mile spatial interval to provide input to cost-benefit analyses performed as part of regulatory, backfit, or environmental analyses. Furthermore, economic costs and other socio-economic indicators (e.g., the extent of land contaminated or population affected by protective actions) are also sometimes estimated in PRA studies performed for research purposes to provide additional insights that can be used to either: (1) check for consistency with other correlated results, or (2) evaluate results from a different perspective.

As shown in Table 4-4, as reproduced in Table 5-18, the frequency-weighted mean annual economic cost risk within 50 miles is 72,000 2015 U.S. dollars (USD) per calendar-year and the frequency-weighted mean annual economic cost risk within 100 miles is 1,100,000 2015 USD per calendar-year. These values were obtained by weighting the conditional mean (over all weather trials) consequence values for individual release categories by the point estimate of the individual release category frequencies. Also shown for comparison in Table 5-18 are the summary economic cost risk measures from at-power scenarios, adapted from Table 5-40 of NRC (2023). It may be noted that the mean annual economic cost risk from LPSD internal event scenarios is about comparable to the mean annual economic cost risk from reactor, at-power, internal event and internal flood scenarios and is less than one-half of the reactor, at-power, risk from all hazards combined. The ratios between the at-power and the LPSD scenarios are broadly like those seen in Table 5-12 but are not identical because there is a non-linear relationship between land contamination levels and the resulting economic impacts.

Table 5-18 Summary of Economic Cost Risk Measures

Scope Piece	Release Freq. (/yr)	Total Economic Cost Risk, 0–50 mi (2015$/yr)[1]	Total Economic Cost Risk, 0–100 mi (2015$/yr)[1]
LPSD (Internal events)	1.2E-05	72,000	110,000
At-Power (Internal events and internal floods)	6.4E-05[2]	74,000	89,000
At-Power (All hazards)[3]	1.6E-04[2]	220,000	260,000

[1] *Results are a frequency-weighted sum of all release categories. Reactor at-power results are based on reactor-years. To convert the risk metric of the **reactor at-power** from per reactor-year to per calendar-year, multiply the result by the plant availability factor of 0.93. Note, the resulting reactor, at-power, calendar-year risk does not include the risk associated with reactor shutdown operations during the calendar year.*

[2] *Frequency of reactor at-power events are given in reactor-years. To convert the release frequency of the **reactor at-power** from per reactor-year to per calendar-year, multiply the frequency by the plant availability factor of 0.93. Note, the resulting reactor, at-power, calendar-year release frequency does not include the contribution from reactor shutdown operations during the calendar year.*

[3] *Includes at-power internal events, internal floods, internal fires, seismic events, and high-wind events.*

5.6.1 CCDF Curves and Summary Tables of Exceedance Frequencies

Figure 5-12 and Figure 5-13 display sets of CCDF curves that illustrate the frequencies of exceeding specified levels of economic costs within 50 miles and 100 miles of the reference nuclear power plant site, respectively. As shown in Figure 5-12 and Figure 5-13, most (approximately 50 percent) of the modeled core damage frequency is associated with events resulting in economic costs less than approximately 30 million dollars. There is a sharp drop in exceedance frequency of economic costs at approximately 30 million. The slopes of the CCDF curves appear to become more negative starting at about 1 billion 2015$. Economic costs exceeding 10 billion 2015$ are increasingly unlikely with the frequency of costs greater than 100 billion 2015$ dropping precipitously. Examination of Figure 5-12 and Figure 5-13 and their underlying data reveal that (at a frequency of less than 1×10^{-11} per calendar-year) the maximum economic costs across all modeled accident scenarios and all weather trials is about 160 billion 2015$ for the 0–50-mile region and about 350 billion 2015$ for the 0–100-mile region.

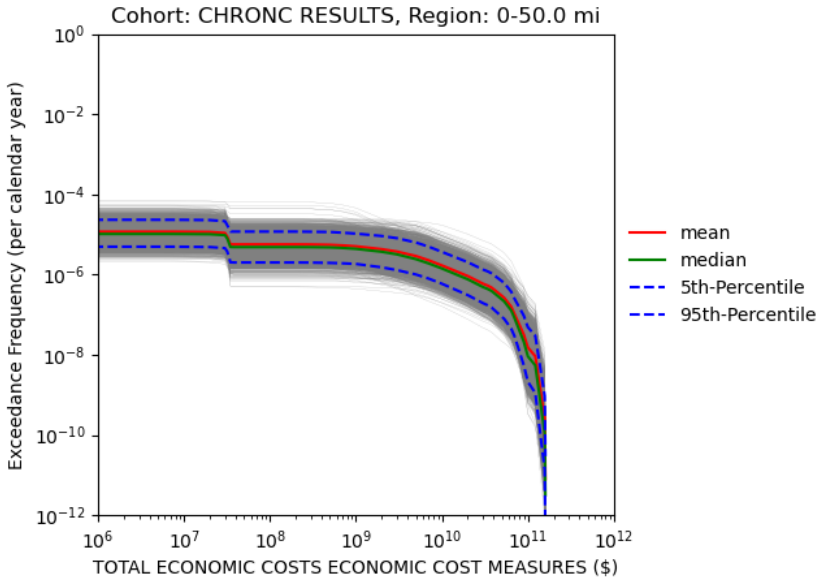


Figure 5-12 CCDF Curves of Uncertain Total Economic Costs within the 0–50-Mile Interval

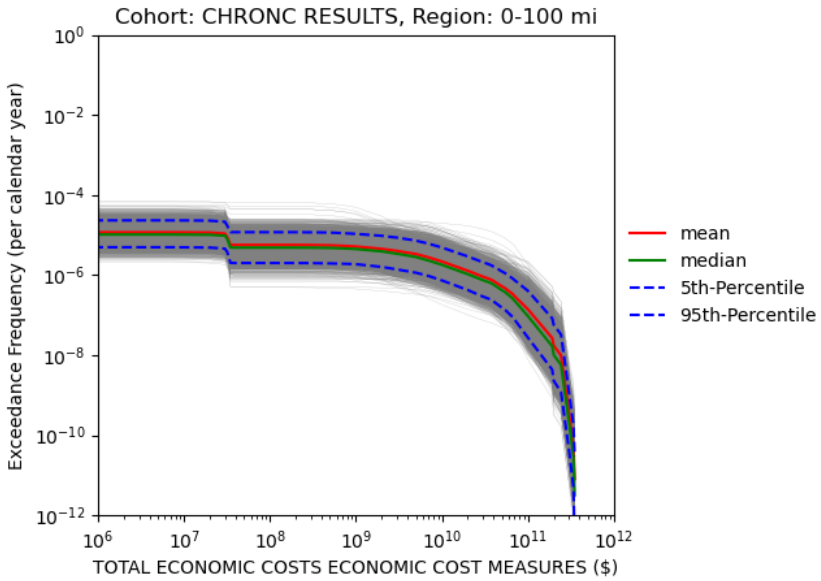


Figure 5-13 CCDF Curves of Uncertain Total Economic Costs within the 0–100-Mile Interval

CCDF curves are presented because they are consistent with PRA state-of-practice and were used in the NUREG-1150 summary report. Table 5-19 and Table 5-20 summarize the mean exceedance frequencies and the 90 percent probability intervals for the frequencies of exceeding specified levels of total economic costs within 50 miles and 100 miles, respectively.

Table 5-19 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Levels of Total Economic Costs (0–50 Miles)

Total Economic Costs (2015 USD) (0–50 miles)	Mean Exceedance Frequency (/yr)	Exceedance Frequency 90% Probability Interval (/yr)
$1x10^8$ (100 million)	5.7E-06	2.0E-06 – 1.2E-05
$1x10^9$ (1 billion)	5.1E-06	1.9E-06 – 1.1E-05
$1x10^{10}$ (10 billion)	1.7E-06	5.9E-07 – 3.7E-06

Table 5-20 Mean and 90% Confidence Intervals for Exceedance Frequencies of Specified Levels of Total Economic Costs (0–100 Miles)

Total Economic Costs (2015 USD) (0–100 miles)	Mean Exceedance Frequency (/yr)	Exceedance Frequency 90% Probability Interval (/yr)
$1x10^8$ (100 million)	5.7E-06	2.0E-06 – 1.2E-05
$1x10^9$ (1 billion)	5.2E-06	1.9E-06 – 1.1E-05
$1x10^{10}$ (10 billion)	2.2E-06	7.4E-07 – 4.9E-06

5.6.2 Significant Contributors to Risk

Figure 4-50 and Figure 4-51 illustrate the relative contributions of each modeled radiological release category to the mean annual risk of total economic costs within 50 miles and 100 miles, respectively. These figures show that the release category that makes the largest contribution to mean annual risk of total economic costs within both 50 and 100 miles is a release category in which the containment fails due to overpressure by steam sometime in between the start of the accident and the start of core damage (SD-CF-Before-CD). This release category contributes 53 percent and 45 percent of the mean annual risk of total economic costs within 50 and 100 miles, respectively. Also, taken together, the three release categories that involve an open containment hatch and/or personnel airlock, with operator failure to reclose them (SD-COPEN-HEADOFF, SD-COPEN-RCSINTACT, SD-COPEN-RCSVENT), collectively contribute 25 percent (within 50 miles) to 38 percent (within 100 miles) of the mean annual risk of total economic costs. A release category in which the release to the environment occurs via a containment penetration that fails to be isolated by manual action or via a pre-existing leakage path (not including open containment hatch or personnel airlock) (SD-CIF) contributes an additional 13 percent (within 100 miles) to 17 percent (within 50 miles).

The basic events in the integrated Level 1 and Level 2 PRA logic models that have a composite FV importance greater than 0.005 for mean annual risk of total economic costs within both 50 and 100 miles, for the reactor at-shutdown, are mostly in common for both risk metrics. Review of the composite FV importance rankings reveals that, for the reactor at-shutdown, LOOP is the initiating event contributing by far the most to mean annual risk of total economic costs within both 50 and 100 miles (over 80 percent). Other initiating event contributors with the

reactor at-shutdown (all in the 4–5 percent range) include (1) loss of NSCW, (2) loss of a 4,160 V AC bus, and (3) loss of RHR. Also, the POSs with the largest contribution to mean annual risk of total economic costs within both 50 and 100 miles are refueling operation (61–68 percent) or when the pressurizer is water solid for hydrogen degassing prior to refueling (14 percent). The POS for draining the RCS to mid-loop prior to refueling also contributes approximately 6 percent (within 50 miles) to 9 percent (within 100 miles).

Aside from the boundary condition basic events (i.e., related to plant operating type and state) and initiating events, most of the highest contributing events involve various human errors (e.g., failures to restore electric power, failure to establish low-pressure gravity feed given LOOP, failure of emergency closure of the equipment hatch with no AC power available, or failure to isolate small containment penetrations [with high dependency on a previous operator failure]). Other high contributing events include failures leading to a station blackout (e.g., failures of diesel generators, RAT input breakers, or load sequencers).

5.7 Risk Integration Summary

The main objective of the Risk Integration technical element is to combine the results from the Level 2 radiological release frequency analysis with the corresponding results from the Level 3 offsite radiological consequence analysis to provide an overall characterization of the risk to the offsite public from a broad spectrum of postulated accidents involving a modeled nuclear power plant site. This overall characterization includes a characterization of uncertainty and identification of significant contributors to risk. It is important to note that the uncertainty characterization presented in Section 5 does not include the following sources of uncertainty: (1) epistemic uncertainty arising from imperfect knowledge about the values of some input parameters for phenomena represented in the Level 2 PRA logic model, the Level 2 PRA severe accident progression models, or in the Level 3 PRA offsite radiological consequence models; (2) epistemic uncertainty arising from imperfect knowledge about systems or phenomena modeled in the PRA (model uncertainty); and (3) epistemic uncertainty arising from limitations in the scope of the PRA model (completeness certainty). As previously stated, the SOARCA uncertainty analyses for the Peach Bottom, Surry, and Sequoyah plants involved varying multiple uncertain model parameters in the severe accident progression and offsite radiological consequence models for specific accident scenarios to quantify uncertainty and to determine which parameters have the greatest influence on the results. Insights from these uncertainty analyses offer an additional perspective that can be used to supplement the limited treatment of these sources of uncertainty in the L3PRA project.

Since some results that are traditionally considered products of the risk integration technical element were presented in Section 4, Section 5 focuses on documenting methods and results that were not already addressed. However, the following key points from Section 4.7, regarding the L3PRA project results, are worth reiterating here:

- There is an extremely low likelihood of the high doses needed for the induction of early health effects.

- The vast majority of the radiological exposure after a severe accident arises from reoccupation of land, and the number of latent cancer fatalities attributable to this level of radiation exposure are not anticipated to be statistically observable above the expected number of cancer fatalities in the exposed population from all other causes.

The bulk of the radiological exposure arising from reoccupation of land after decontamination and natural decay and weathering reduce exposures to levels below the habitability criteria assumed in the analysis (i.e., 2 rem in the year of the accident and 500 mrem per year in the years after the accident). These levels are in the low to very low dose range. As discussed in Volume 4, Annex X of IAEA (2015), these levels would give rise to a small hypothetical additional lifetime risk of cancer (less than 0.1 percent). From an epidemiological standpoint, the number of latent cancer fatalities attributable to radiation exposure from accidental releases from a severe accident would unlikely be observable statistically above the expected number of cancer fatalities in the exposed population from all other causes (i.e., the excess cancer fatalities predicted are too few to allow the detection of a statistically significant difference in the cancer fatalities expected from other causes among the same population). The examination of early fatality risk (or comparably, the risk of high exposures) suggests that the extremely low likelihood of high doses to the offsite public are because of the following factors:

- very low frequency of events that would generate relatively large and fast releases
- relatively low frequency of adverse meteorological conditions (primarily stable, low wind speed conditions)
- very sparse close-in population, which limits the likelihood of the wind blowing in the direction of a populated sector very close to the site
- low likelihood of delayed and/or slow evacuation of the populations toward which the winds are blowing

The methods and results addressed specifically in Section 5 include:

- characterizing risk and uncertainty for a selected set of offsite public risk metrics using sets of CCDF curves that reflect both: (1) aleatory uncertainty by considering the full spectrum of modeled accident scenarios and the statistical variability over time in offsite weather conditions, and (2) epistemic uncertainty arising from imperfect knowledge about the values of input parameters in the Level 1 and Level 2 PRA logic models
- identifying and characterizing significant contributors to risk stemming from the events, phenomena, or modeling assumptions in the Level 1 and Level 2 PRA logic models, including: (1) initiating events, (2) random and common-cause component failures, (3) HFEs, (4) phenomenological modeling assumptions, and (5) POSs

Key insights developed from the Risk Integration technical element include:

- There is generally about an order of magnitude in epistemic uncertainty arising from imperfect knowledge about the values of input parameters in the Level 1 and Level 2 PRA logic models. In other words, the points on the 95^{th} and 5^{th} percentile CCDF curves at specified consequence levels generally differ by about a factor of 10 (though this range begins to narrow at the very large consequence levels). Although early health effects are subject to a larger (about a factor of 50) range of uncertainty stemming from the Level 1 and Level 2 PRA logic models, it should be noted that the absolute values for the frequency of non-zero early health effects are nonetheless extremely low (less than 10^{-7} per calendar-year even at the upper end).

- Offsite public risk metrics, other than those that relate to early health effects, are generally dominated by the same radiological release categories, though the specific order may vary: (1) a release category in which the containment fails due to overpressure by steam sometime in between the start of the accident and the start of core damage (SD-CF-Before-CD), (2) a release category in which the release to the environment occurs via a containment penetration that fails to be isolated by manual action or via a pre-existing leakage path (not including open containment hatch or personnel airlock) (SD-CIF); and (3) the three release categories that involve an open containment hatch and/or personnel airlock, with operator failure to reclose them, and for which the release is considered to reach the environment directly via these large openings (SD-COPEN-HEADOFF, SD-COPEN-RCSINTACT, SD-COPEN-RCSVENT). A modest contribution (4–10 percent) also comes from a release category in which the containment fails hours after vessel breach due to a global deflagration or detonation (SD-ICF-BURN), except for land contamination risk, for which SD-ICF-BURN only contributes on the order of 1 percent.

- Offsite public risk metrics that relate to early health effects (which are very low) arise only from the SD-COPEN-RCSVENT and SD-COPEN-HEADOFF release categories, with virtually the entire contribution (99.9 percent) coming from SD-COPEN-RCSVENT. For SD-COPEN-RCSVENT, prior to any breach of the reactor vessel lower head by core debris, the RCS is vented or has a persistent leak not including normally cycling relief valves (e.g., pipe break or manual bleed), such that retention of aerosols inside the RCS may be intermediate in magnitude.

- The accident termination time of 7 days after event initiation is selected for use in the Level 3 PRA analysis. As discussed in Section 2.6.4 of NRC (2022b), this is a longer accident termination time in comparison to past Level 2 PRA studies. This modeling assumption most significantly impacts the ICF-BURN release category, but also results in a noticeable (greater than 10 percent) reduction in the conditional consequences for the COPEN-RCSVENT and COPEN-RCSINTACT release categories. The overall effect of imposing a shorter accident termination time (i.e., 36 hours after entry into the severe accident management guidelines) is to reduce most risk metrics by 12–16 percent, though the reduction is in the general area of 25 percent specifically for population-weighted individual latent cancer fatality risk and risk of population affected by intermediate-phase relocation and is minimal for early fatality risk and land contamination risk. It should be noted, however, that imposing a shorter accident termination time could result in significantly underestimating the release.

- Offsite public risk metrics other than those that relate to early health effects generally have a similar set of significant risk contributors for the reactor at-shutdown, in terms of composite FV importance. In terms of initiating events, LOOP is by far the largest contributor (generally, around 80 percent). Other significant initiating event contributors (generally, in the 3–5 percent range) include (1) loss of NSCW, (2) loss of RHR, (3) loss of a 4,160 V AC bus, and (4) an overdraining event with the reactor in mid-loop operation.

  Also, just two POSs, refueling operation and when the pressurizer is water solid for hydrogen degassing prior to refueling, generally contribute around 80 percent to all offsite public risk metrics other than those that relate to early health effects.

Aside from the boundary condition basic events (i.e., related to plant operating type and state) and initiating events, most of the highest contributing events involve various human errors (e.g., failures to restore electric power, failure to establish low-pressure gravity feed given LOOP, failure to isolate small containment penetrations [with high dependency on a previous operator failure], or failure of emergency closure of the equipment hatch with no AC power available). Other high contributing events include failures leading to a station blackout (e.g., failures of diesel generators, RAT input breakers, or load sequencers).

- Offsite public risk metrics that relate to early health effects also have a similar set of significant risk contributors for the reactor at-shutdown, in terms of composite FV importance. LOOP is the initiating event contributing by far the most (approximately 90 percent), while loss of inventory initiating events collectively contribute an additional 8 percent. Also, approximately 93 percent of early fatality risk occurs in just two POSs, draining the RCS to mid-loop prior to refueling (56 percent) or after refueling (37 percent).

  Aside from the boundary condition basic events and initiating events, the top two basic event contributors to both early fatality risk measures are (1) operator failure to establish low pressure gravity feed given a LOOP (approximately 83 percent) and (2) operator failure to close the equipment hatch with lowered RCS inventory and no AC power (approximately 81 percent). Other significant contributors to early fatality risk include equipment failures or operator errors that lead to a station blackout. Included in this set of basic events are common-cause failures of the RAT input breakers (contributing 33 percent) and the load sequencers (contributing 20 percent), as well as random failures of these components and the diesel generators, and operator failure to recover offsite power.

6 MODEL ERRORS AND POTENTIAL CANDIDATES FOR FUTURE WORK

This section provides a list of known model errors in Table 6-1 and a list of candidates for future work in Table 6-2. The errors in Table 6-1 were not corrected at the time at which they were discovered due to the level of effort needed to correct the error and regenerate all required results. An evaluation of the potential significance of each known error is also included. This list is current as of the time of writing.

The list of candidates for future work provided in Table 6-2 is adapted from NRC (2022a). It has been supplemented to include a candidate analysis to examine the uncertainty associated with the timing of EAL conditions for station blackout scenarios. The identification of candidates for future work was developed by reviewing the uncertainties and limitations associated with each technical element together with a review of comments from internal reviews and the external peer review. Although all the candidate sensitivity analyses identified in Section 3 identify candidates for potential future work, some of these are of higher priority than others. Only those potential candidates for future work that are judged to be of higher priority are included in Table 6-2.

Table 6-1 Known Modeling Errors

Technical Element	Description	Expected Impact	Level of Effort	Notes
EC (Section 3.4.2.5)	After development of the input decks for the Level 3 PRA, an error was identified in the derivation of the values for CDNFRM in Jones, Bixler, and Kimura (2015). Per capita decontamination cost estimates for different land use categories were weighted by land area instead of population.	Low. Preliminary evaluation suggests that correction of this error could result in lowering the per-capita decontamination costs by a factor of less than 2 for DF3 and approximately 15 percent for DF5 and DF15.	Medium to develop corrected parameter estimates. Low to correct input decks. High to re-run all analyses and document results.	This is not expected to be a significant source of error in overall economic results reported in this project because decontamination costs are typically a small fraction of total economic costs in this analysis.
EC (Section 3.4.2.5)	After development of the input decks for the Level 3 PRA project, ongoing work to update the technical basis for decontamination model parameters was completed and published in NUREG/CR-7270 (Bixler et al. 2022).	Moderate. Preliminary sensitivity analyses for reactor at-power source terms suggested that, on a source-term-specific basis, economic costs could increase by factors of up to 2. Individual latent fatality risk within 10 miles could decrease by up to 20 percent due to increased cost-based condemnation.	Low to moderate to develop updated parameter estimates and update input decks. High to re-run all analyses and document results.	Although not a technical error, the public availability of this update was judged to be of sufficient significance to warrant mention in this report.

Table 6-2 Potential Candidates for Future Work

Technical Element	Description	Level of Effort	Expected Impact
RE	It is recommended to confirm the adequacy of the process used to select a representative source term for each release category by explicitly modeling all candidate source terms for each release category.	Medium to develop additional input decks. High to re-run all analyses and document results.	Low-Medium. For the reasons discussed in NRC (2022b), some of the alternate source terms are not good candidates or are expected to represent a small portion of the release category frequency.
ME	The effect of using different years of weather data (i.e., evaluating inter-annual meteorological variability) has not been explicitly assessed.	Medium to develop weather file for alternate years of data. High to re-run all analyses and document results.	Low. Minor changes in most results. Potentially noticeable change for low frequency results characterized by high-dose thresholds (i.e., early injuries or fatalities).
AT	An alternative to the original MACCS Gaussian plume segment model that allows MACCS to use results computed by the NOAA HYSPLIT code (Stein et al. 2015) has been developed. Use of the new capability may allow assessment of the uncertainty introduced by use of a Gaussian plume segment model at long distances.	High for all phases.	Not assessed.

Table 6-2 Potential Candidates for Future Work (cont.)

Technical Element	Description	Level of Effort	Expected Impact
PA	The methodology for developing relocation times remains under development. It is recommended to examine the effect of updated methodologies when that work is completed.	Low to update input decks with revised recommendations. High to re-run all analyses and document results.	Low overall. There may be increased early-phase doses to non-evacuating cohorts with longer relocation times; limited effect overall due to dominance of CHRONC results. Although early health effect estimates are expected to be more sensitive to early-phase relocation times, risk numbers are still expected to remain very low because relocation only applies to the non-evacuating cohort, which is a small fraction of the population within 10 miles.
PA	There is uncertainty in estimating the timing of GE declarations arising from station blackout sequences occurring during cold operating conditions.	Medium-High to independently assess and revise current approach. High to re-run all analyses and document results.	Low-medium. Limited effects expected due to expected dominance of CHRONC results. However, this uncertainty could be significant for early-phase exposures if the declaration of a GE were delayed sufficiently that the warning time was insufficient to allow evacuation of the EPZ prior to release.
PA	There is uncertainty in the time at which evacuation may be ordered beyond the EPZ. It is believed that there is no current state-of-practice approach for development of MACCS model timings for evacuation beyond the EPZ.	Medium-High to independently assess and revise current approach. High to re-run all analyses and document results.	Low overall. Although there may be an increase in early-phase doses to late evacuating cohorts with more delayed evacuations (or conversely, a decrease in early-phase doses with more rapid evacuation), it is expected that there would be a limited effect overall due to dominance of CHRONC results and because the 10-mile region would not be affected by this modeling approach.

Table 6-2 Potential Candidates for Future Work (cont.)

Technical Element	Description	Level of Effort	Expected Impact
PA	The methodology for developing shielding factors (e.g., GSHFAC, PROTIN, and CSFACT) remains under development. It is recommended to examine the effect of updated methodologies when that work is completed.	Low to update input decks with revised recommendations. High to re-run all analyses and document results.	Medium. Doses expected to be proportional to shielding factors.
EC	The effect of the MACCS modeling of the intermediate and recovery phase relocation and habitability decision-making (reflected in MACCS parameters such as DUR_INTPHAS, DPP_INTPHAS, DSCRTI, TMPACT, DSCRLT, and TIMDEC) might significantly affect long term doses and costs, which appear to drive many results.	High to develop alternate parameters and to update input decks. High to re-run all analyses and document results.	Medium. Population doses expected to be proportional to habitability criteria. Costs expected to be inversely proportional to habitability criteria.
EC	Examine influence of decontamination plan (levels and unit costs) on dose and cost results.	Medium to develop alternate parameters and to update input decks. High to re-run all analyses and document results.	Medium. Increased unit costs expected to increase economic impacts. Very high unit costs may result in increased condemnation of farmland and non-farmland, resulting in higher costs but lower doses.
EC	An alternative to the original MACCS economic model that uses input-output methods is under development. It is recommended to examine the impact of this alternate conceptual model once that code development work is completed and accepted.	High for all phases.	Not assessed.
DO*	In contrast to the version of MACCS used to develop the input decks (WinMACCS 3.10), WinMACCS 3.11 introduced the capability to explicitly model all organs identified in FGR-13 cancer risk models. Explicit modeling	High to develop alternate input decks. High to re-run all analyses and document results.	Low. Total cancer risk results not expected to change significantly. Non-cancer risk metrics should be unaffected.

Table 6-2 Potential Candidates for Future Work (cont.)

Technical Element	Description	Level of Effort	Expected Impact
	of all FGR-13 cancer risk organs could confirm the adequacy of the current approach, based on SOARCA precedent for implementing the FGR-13 cancer risk model.		
QT	The results of the study are not compared to the results of other studies.	High to identify and evaluate appropriate studies for comparison and to document reasons for differences.	None.
QT/RI	Explicit uncertainty analyses propagating parameter uncertainty distributions for uncertain MACCS parameters, as identified in the SOARCA uncertainty analyses and review of other sources, would provide an indication of the uncertainty in overall risk results arising from uncertain MACCS input parameters.	High for all phases.	None.

* *This potential future work would take advantage of the capabilities introduced with WinMACCS 3.11 to explicitly model risks to any organ specified in the DCF file, rather than the nine hardwired organs available in WinMACCS 3.10 and earlier.*

7 REFERENCES

American Nuclear Society / American Society of Mechanical Engineers (ANS/ASME), 2010. Radiological Accident Offsite Consequence Analysis (Level 3 PRA) to Support Nuclear Installation Applications (ANS/ASME-58.25) (DRAFT). LaGrange Park, IL: American Nuclear Society.

American Society of Mechanical Engineers / American Nuclear Society (ASME/ANS), 2015. Standard for Radiological Accident Offsite Consequence Analysis (Level 3 PRA) to Support Nuclear Installation Applications (ASME/ANS RA-S-1.3) (DRAFT). La Grange Park, IL: American Nuclear Society.

American Society of Mechanical Engineers / American Nuclear Society (ASME/ANS), 2017. Standard for Radiological Accident Offsite Consequence Analysis (Level 3 PRA) to Support Nuclear Installation Applications (ASME/ANS RA-S-1.3-2017) (Draft for Trial Use and Pilot Application). La Grange Park, IL: American Nuclear Society.

Atkinson, D., and R.F. Lee, 1992. *Procedures for Substituting Values for Missing NWS Meteorological Data for Use in Regulatory Air Quality Models*, July 7, 1992, http://www.rflee.com/RFL_Pages/missdata.pdf.

Bixler, N., E. Clauss, and C.W. Morrow, 2013. Synthesis of Distributions Representing Important Non-Site-Specific Parameters in Offsite Consequence Analysis (NUREG/CR-7161 / SAND2010-3380P). Albuquerque, NM: Sandia National Laboratories, April 2013. (ADAMS Accession No. ML13114A322)

Bixler, N. K. Compton, M. Dennis, L. Eubanks, R. Haaker, J. Jones, M. Kimura, K. McFadden, A. Nosek, A. Outkin, and F. Walton, 2022. Technical Bases for Consequence Analyses Using MACCS (MELCOR Accident Consequence Code System) (NUREG/CR-7270 / SAND2022-12166 R). Albuquerque, NM: Sandia National Laboratories, October 2022 (ADAMS Accession No. ML22294A091)

Breeding, R.J., J.C. Helton, W.B. Murfin, and L.N. Smith, 1990. *Evaluation of Severe Accident Risks: Surry Unit 1. Volume 3, Rev 1, Part 1: Main Report (NUREG/CR-4551 / SAND86-1309)*. Albuquerque, NM: Sandia National Laboratories, October 1990. (ADAMS Accession No. ML070540210)

Burke, R.P., D.C. Aldrich, and N.C. Rasmussen, 1984. *Economic Risks of Nuclear Power Reactor Accidents (NUREG/CR-3673 / SAND84-0178)*, Albuquerque, NM: Sandia National Laboratories, April 1984. (ADAMS Accession No. ML103050360)

Chanin, D. and M.L. Young, 1998. "*Code Manual for MACCS2: Volume 1, User's Guide" (NUREG/CR-6613 / SAND97-0594).* Albuquerque, NM: Sandia National Laboratories, May 1998. (ADAMS Accession No. ML110030976)

Eckerman, K.F., 2012. Letter Report, "Radiation Dose and Health Risk Estimation: Technical Basis for the State-of-the-Art Reactor Consequence Analysis Project," Oak Ridge National Laboratory: Oak Ridge, TN, January 2012. (ADAMS Accession No. ML12159A259)

Goossens, L.H.J., J. Boardman, B.C.P. Kraan, R.M. Cooke, J.A. Jones, F.T. Harper, M.L. Young, and S.C. Hora, 1997. Probabilistic Accident Consequence Uncertainty Analysis, Uncertainty Assessment for Deposited Material and External Doses, Volumes 1 and 2 (NUREG/CR-6526 / EUR16772 / SAND97-2323). Brussels, Belgium: Commission of the European Communities, and Washington, DC: U.S. Nuclear Regulatory Commission, December 1997

Goossens, L.H.J, J.D. Harrison, B.C.P. Kraan, R.M. Cooke, F.T. Harper, and S.C. Hora, 1998. Probabilistic Accident Consequence Uncertainty Analysis, Uncertainty Assessment for Internal Dosimetry, Volumes 1 and 2" (NUREG/CR-6571 / EUR16773 / SAND98-0119). Brussels, Belgium: Commission of the European Communities, and Washington, DC: U.S. Nuclear Regulatory Commission, April 1998

Grogan, H.A., Sinclair, W.K., Voilleque, P.G., 2001. Risks of fatal cancer from inhalation of 239,240 plutonium by humans: a combined four-method approach with uncertainty evaluation. Health Phys. 80, 447–461, Erratum in: Health Phys. 2002; 82, 404. Cited in ICRP (2005)

Harper, F. T., S.C. Hora, M.L. Young, L.A. Miller, C.H. Lui, M.D. McKay, J.C. Helton, L.H.J Goossens, R.M. Cooke, J.Pasler-Sauer, B. Kraan, and J.A. Jones, 1995. *Probabilistic Accident Consequence Uncertainty Analysis, Dispersion and Deposition Uncertainty Assessment, Volumes 1 and 2 (NUREG/CR-6244 / EUR 15855EN / SAND94-1453)*, Brussels, Belgium: Commission of the European Communities, and Washington, DC: U.S. Nuclear Regulatory Commission, January 1995. (Volume 1, ML010670124; Volume 2, ML010670239; Volume 3, ML010670167)

Haskins, F.E., F.T. Harper, L.H.J. Goossens, B.C.P. Kraan, and J.B. Grupa, 1997. Probabilistic Accident Consequence Uncertainty Analysis, Early Health Effects Uncertainty Assessment, Volumes 1 and 2 (NUREG/CR-6545 / EUR16775EN / SAND97-2689), Brussels, Belgium: Commission of the European Communities, and Washington, DC: U.S. Nuclear Regulatory Commission, December 1997.

Health Physics Society (HPS), 2010. "Radiation Risk in Perspective: Position Statement of the Health Physics Society" (PS010-2). Adopted January 1996, Revised July 2010. McLean, VA.

Helton, J. C., J. D. Johnson, J. A. Rollstin, A. W. Shiver, and J. L. Sprung, 1995a. Uncertainty and Sensitivity Analysis of Chronic Exposure Results with the MACCS Reactor Accident Consequence Model (NUREG/CR-6134 / SAND93-2370), Sandia National Laboratories, Albuquerque, NM, January 1995.

Helton, J. C., J. D. Johnson, M. D. McKay, A. W. Shiver, and J. L. Sprung, 1995b. Uncertainty and Sensitivity Analysis of Early Exposure Results with the MACCS Reactor Accident Consequence Model (NUREG/CR-6135 / SAND93-2371), Sandia National Laboratories, Albuquerque, NM, January 1995.

Humphries, L.L., R.K. Cole, D.L. Louie, V.G. Figueroa, and M. F. Young, 2015. *MELCOR Computer Code Manuals, Vol. 2: Reference Manual, Version 2.1.6840 2015 (SAND2015-6692 R).* Albuquerque, NM: Sandia National Laboratories.

International Atomic Energy Agency (IAEA), 2001. *Present and Future Environmental Impact of the Chernobyl Accident (IAEA-TECDOC-1240).* Vienna, Austria: International Atomic Energy Agency, 2001.

International Atomic Energy Agency (IAEA), 2015. *The Fukushima Daiichi Accident (STI/PUB/1710)*. Vienna, Austria: International Atomic Energy Agency, August 2015

International Commission on Radiological Protection (ICRP), 2005. Low-dose Extrapolation of Radiation-related Cancer Risk (ICRP Publication 99), Ann. ICRP 35(4)

International Commission on Radiological Protection (ICRP), 2007. The 2007 Recommendations of the International Commission on Radiological Protection (ICRP Publication 103), Ann. ICRP 37(2-4)

Jones, J., 1983. “Models to Allow for the Effects of Coastal Sites, Plume Rise and Buildings on Dispersion of Radionuclides and Guidance on the Value of Deposition Velocity and Washout Coefficients” (NRPB-R157), National Radiological Protection Board, England. Cited in Chanin and Young 1998.

Jones, J., F. Walton, N. Bixler, and B. Wolshon, 2015. “Letter Report: Level 3 PRA MACCS Emergency Preparedness Parameters”. Albuquerque, NM: Sandia National Laboratories, April 2015. (ADAMS Accession No. ML15146A459)

Jones, J., N. Bixler, and M. Kimura, 2015. "Update of MACCS Cost Parameters Related to Protective Measures and Decontamination (Draft)." Albuquerque, NM: Sandia National Laboratories. (ADAMS Accession No. ML15288A523)

Little, M.P., C.R. Muirhead, L.H.J Goossens, B.C.P. Kraan, R.M. Cooke, F.T. Harper, and S.C. Hora, 1997. Probabilistic Accident Consequence Uncertainty Analysis, Late Health Effects Uncertainty Assessment, Volumes 1 and 2” (NUREG/CR-6555 / EUR 16774 / SAND97-2322), Brussels, Belgium: Commission of the European Communities and Washington, DC: U.S. Nuclear Regulatory Commission, December 1997.

Molenkamp, C.R., N.E. Bixler, C.W. Morrow, J.V. Ramsdell, and J.A. Mitchell, 2004. Comparison of Average Transport and Dispersion Among a Gaussian, a Two-Dimensional, and a Three-Dimensional Model (NUREG/CR-6853). Livermore, CA: Lawrence Livermore National Laboratory, Albuquerque, NM: Sandia National Laboratories, and Richland, WA: Pacific Northwest National Laboratory, October 2004. (ADAMS Accession No. ML043240034)

Mubayi, V., V. Sailor, and G. Anandalingam, 1995. *Cost-Benefit Considerations in Regulatory Analysis (NUREG/CR-6349 / BNL-NUREG-52466)*, Brookhaven National Laboratory, Upton, NY, October 1995. (ADAMS Accession No. ML103050362)

National Cancer Institute/Centers for Disease Control and Prevention (NCI/CDC), 2003. Report of the NCI-CDC Working Group to revise the 1985 NIH Radioepidemiological Tables (NIH Publication No. 03-5387). Bethesda, MD: US Dept. of Health and Human Services, National Institutes of Health, National Cancer Institute, 2003.

National Council on Radiation Protection and Measurements (NCRP), 1997. Uncertainties in Fatal Cancer Risk Estimates Used in Radiation Protection. (NCRP Report No. 126)

Bethesda, MD: National Council on Radiation Protection and Measurements. Cited in (ICRP 2005).

Pawel D. J., R. W. Leggett, K.F. Eckerman, and C.B. Nelson, 2007. *Uncertainties in Cancer Risk Coefficients for Environmental Exposure to Radionuclides (ORNL/TM-2006/583)*, Oak Ridge, TN: Oak Ridge National Laboratory, January 2007.

Sandia National Laboratories (SNL), 2016. State-of-the-Art Reactor Consequence Analyses Project: Uncertainty Analysis of the Unmitigated Long-Term Station Blackout of the Peach Bottom Atomic Power Station (NUREG/CR-7155). NUREG/CR, Albuquerque, NM: Sandia National Laboratories, May 2016. (ADAMS Accession No. ML16133A461)

Sandia National Laboratories (SNL), 2019. State-of-the-Art Reactor Consequence Analyses (SOARCA) Project: Sequoyah Integrated Deterministic and Uncertainty Analyses (NUREG/CR-7245). Albuquerque, NM: Sandia National Laboratories, October 2019. (ADAMS Accession No. ML19296B786)

Sprung, J.L., J. A. Rollstin, J. C. Helton, and H-N Jow., 1990. Evaluation of Severe Accident Risks: Quantification of Major Input Parameters, Volume 2, Rev. 1, Part 7: MACCS Input (NUREG/CR-4551 / SAND86-1309), Albuquerque, NM: Sandia National Laboratories, December 1990.

U.S. Environmental Protection Agency (EPA), 1985. *Guideline for Determination of Good Engineering Practice Stack Height, Revised (EPA-450-4-80-023R)*, Washington DC: U.S. Environmental Protection Agency, June 1985.

U.S. Environmental Protection Agency (EPA), 1999a. *Federal Guidance Report 13: Cancer Risk Coefficients for Environmental Exposure to Radionuclides (EPA 402-R-99-001)*, Washington DC: U.S. Environmental Protection Agency, September 1999.

U.S. Environmental Protection Agency (EPA), 1999b. Estimating Radiogenic Cancer Risks (EPA 402-R-00-003) Estimating Radiogenic Cancer Risks Addendum: Uncertainty Analysis (EPA 402-R-99-003). Washington DC: U.S. Environmental Protection Agency, May 1999.

U.S. Environmental Protection Agency (EPA), 2011. *Exposure Factors Handbook (EPA/600/R-090/052F).* Washington, DC: U.S. Environmental Protection Agency, September 2011.

U.S. Nuclear Regulatory Commission (NRC), 1986. Safety Goals for the Operations of Nuclear Power Plants; Policy Statement; Republication (51 FR 30028), Federal Register.

U.S. Nuclear Regulatory Commission (NRC), 1990. *Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants (NUREG-1150)*, Washington DC: U.S. Nuclear Regulatory Commission, December 1990.

U.S. Nuclear Regulatory Commission (NRC), 2011a. Staff Requirements – SECY-11-0089 – Options for Proceeding With Future Level 3 Probabilistic Risk Assessment (PRA) Activities (SRM-SECY-11-0089). Washington DC: U.S. Nuclear Regulatory Commission, September 2011. (ADAMS Accession No. ML112640419)

U.S. Nuclear Regulatory Commission (NRC), 2011b. Options for Proceeding with Future Level 3 Probabilistic Risk Assessment Activities (SECY-11-0089). Washington DC: U.S. Nuclear Regulatory Commission, July 2011. (ADAMS Accession No. ML11090A039)

U.S. Nuclear Regulatory Commission (NRC), 2012. *State-of-the-Art Reactor Consequence Analyses (SOARCA) Report (NUREG-1935)*, Washington DC: U.S. Nuclear Regulatory Commission, November 2012. (ADAMS Accession No. ML12332A057)

U.S. Nuclear Regulatory Commission (NRC), 2013. Technical Analysis Approach Plan for Level 3 PRA Project (Rev. 0b – Working Draft). Washington DC: U.S. Nuclear Regulatory Commission, October 2013. (ADAMS Accession No. ML13296A064)

U.S. Nuclear Regulatory Commission (NRC), 2022a, "*U.S. NRC Level 3 Probabilistic Risk Assessment (PRA) Project, Volume 3d: Reactor, At-Power, Level 3 PRA for Internal Events and Floods*," April 2022a (ADAMS Accession No. ML22067A215)

U.S. Nuclear Regulatory Commission (NRC), 2022b. *U.S. NRC Level 3 Probabilistic Risk Assessment (PRA) Project, Volume 3c: Reactor, At-Power, Level 2 PRA for Internal Events and Floods.* Washington, DC: U.S. Nuclear Regulatory Commission (ADAMS Accession No. ML22067A214)

U.S. Nuclear Regulatory Commission (NRC) 2023, *U.S. NRC Level 3 Probabilistic Risk Assessment Project, Volume 4e: Level 3 PRA for Internal Fires, Seismic Events, and High Winds*, August 2023 (ADAMS Accession No. ML23194A014).

U.S. Nuclear Regulatory Commission (NRC) 2025, *U.S. NRC Level 3 Probabilistic Risk Assessment Project, Volume 5b: Reactor, At-Shutdown, Level 2 PRA for Internal Events*, September 2025 (ADAMS Accession No. ML25157A086).

APPENDIX A
MACCS PLUME SEGMENT DEFINITIONS

Appendix A provides tables of MACCS input parameters that were considered too lengthy (generally tables requiring more than two pages) to include in the body of the report. The tables in Appendix A comprise:

- Table A-1 MACCS Plume Segment Characteristics
- Table A-2 Plume Segment Release Fractions
- Table A-3 Chemical Group Release Fraction by Particle Size Distribution

Table A-1 MACCS Plume Segment Characteristics

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD01	1	820	2.79E+03	7.06E-04	8.51E-01	3.49E+05	2.15E+04
SD01	2	821	2.32E+03	5.85E-04	8.51E-01	3.49E+05	2.15E+04
SD01	3	824	1.25E+03	3.17E-04	8.51E-01	3.49E+05	2.15E+04
SD01	4	820	3.13E+03	8.52E-04	7.52E-01	3.71E+05	2.15E+04
SD01	5	821	2.62E+03	7.18E-04	7.68E-01	3.71E+05	2.15E+04
SD01	6	824	1.42E+03	3.89E-04	7.68E-01	3.71E+05	2.15E+04
SD01	7	27	3.59E+06	8.49E-01	1.17E+00	3.82E+05	3.59E+03
SD01	8	27	3.60E+06	8.51E-01	1.17E+00	3.85E+05	3.50E+03
SD01	9	27	3.59E+06	8.50E-01	1.17E+00	3.89E+05	3.50E+03
SD01	10	27	3.59E+06	8.50E-01	1.17E+00	3.92E+05	4.00E+03
SD01	11	820	3.13E+03	9.15E-04	7.43E-01	3.92E+05	2.20E+04
SD01	12	821	2.59E+03	7.59E-04	7.43E-01	3.92E+05	2.20E+04
SD01	13	824	1.40E+03	4.11E-04	7.43E-01	3.92E+05	2.20E+04
SD01	14	27	3.59E+06	8.50E-01	1.17E+00	3.96E+05	3.50E+03
SD01	15	27	3.59E+06	8.50E-01	1.17E+00	4.00E+05	3.50E+03
SD01	16	27	3.59E+06	8.50E-01	1.17E+00	4.03E+05	3.50E+03
SD01	17	27	3.59E+06	8.50E-01	1.17E+00	4.07E+05	3.50E+03
SD01	18	27	3.59E+06	8.51E-01	1.17E+00	4.10E+05	4.00E+03
SD01	19	27	3.59E+06	8.51E-01	1.17E+00	4.14E+05	3.50E+03
SD01	20	820	3.42E+03	1.00E-03	7.13E-01	4.14E+05	2.15E+04
SD01	21	821	2.83E+03	8.32E-04	7.13E-01	4.14E+05	2.15E+04
SD01	22	824	1.54E+03	4.51E-04	7.13E-01	4.14E+05	2.15E+04
SD01	23	27	3.59E+06	8.51E-01	1.17E+00	4.18E+05	3.50E+03
SD01	24	27	3.59E+06	8.52E-01	1.17E+00	4.21E+05	3.50E+03
SD01	25	27	3.59E+06	8.52E-01	1.17E+00	4.25E+05	3.50E+03
SD01	26	27	3.58E+06	8.49E-01	1.17E+00	4.28E+05	4.00E+03
SD01	27	27	3.55E+06	8.42E-01	1.17E+00	4.32E+05	3.50E+03
SD01	28	27	3.57E+06	8.46E-01	1.17E+00	4.36E+05	3.50E+03
SD01	29	820	3.56E+03	1.11E-03	6.48E-01	4.36E+05	2.15E+04
SD01	30	821	2.97E+03	9.36E-04	6.63E-01	4.36E+05	2.15E+04
SD01	31	824	1.61E+03	5.07E-04	6.63E-01	4.36E+05	2.15E+04
SD01	32	27	3.58E+06	8.49E-01	1.17E+00	4.39E+05	3.50E+03
SD01	33	27	3.58E+06	8.50E-01	1.17E+00	4.43E+05	3.50E+03
SD01	34	27	3.58E+06	8.50E-01	1.17E+00	4.46E+05	4.00E+03
SD01	35	27	3.63E+06	8.60E-01	1.17E+00	4.50E+05	3.50E+03
SD01	36	27	3.64E+06	8.64E-01	1.17E+00	4.54E+05	3.50E+03
SD01	37	27	3.57E+06	8.48E-01	1.17E+00	4.57E+05	3.50E+03
SD01	38	820	2.82E+03	1.14E-03	6.57E-01	4.57E+05	2.15E+04
SD01	39	821	2.34E+03	9.45E-04	6.57E-01	4.57E+05	2.15E+04
SD01	40	824	1.27E+03	5.12E-04	6.58E-01	4.57E+05	2.15E+04

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD01	41	27	3.55E+06	8.43E-01	1.17E+00	4.61E+05	3.50E+03
SD01	42	27	3.55E+06	8.42E-01	1.17E+00	4.64E+05	4.00E+03
SD01	43	27	3.55E+06	8.42E-01	1.17E+00	4.68E+05	3.50E+03
SD01	44	27	3.56E+06	8.44E-01	1.17E+00	4.72E+05	3.50E+03
SD01	45	27	3.55E+06	8.43E-01	1.17E+00	4.75E+05	3.50E+03
SD01	46	27	3.55E+06	8.43E-01	1.17E+00	4.79E+05	3.50E+03
SD01	47	820	3.09E+03	1.24E-03	6.49E-01	4.79E+05	2.13E+04
SD01	48	821	2.56E+03	1.03E-03	6.50E-01	4.79E+05	2.13E+04
SD01	49	824	1.39E+03	5.57E-04	6.50E-01	4.79E+05	2.13E+04
SD01	50	27	3.55E+06	8.43E-01	1.17E+00	4.82E+05	4.00E+03
SD01	51	27	3.55E+06	8.42E-01	1.17E+00	4.86E+05	3.50E+03
SD01	52	27	3.55E+06	8.42E-01	1.17E+00	4.90E+05	3.50E+03
SD01	53	27	3.54E+06	8.40E-01	1.17E+00	4.93E+05	3.60E+03
SD01	54	27	3.55E+06	8.42E-01	1.17E+00	4.97E+05	3.20E+03
SD01	55	27	3.55E+06	8.42E-01	1.17E+00	5.00E+05	4.00E+03
SD01	56	820	3.43E+03	1.36E-03	6.32E-01	5.00E+05	2.16E+04
SD01	57	821	2.84E+03	1.13E-03	6.32E-01	5.00E+05	2.16E+04
SD01	58	824	1.54E+03	6.13E-04	6.32E-01	5.00E+05	2.16E+04
SD01	59	27	3.54E+06	8.41E-01	1.17E+00	5.04E+05	3.20E+03
SD01	60	27	3.54E+06	8.41E-01	1.17E+00	5.07E+05	4.00E+03
SD01	61	27	3.54E+06	8.40E-01	1.17E+00	5.11E+05	3.20E+03
SD01	62	27	3.54E+06	8.41E-01	1.17E+00	5.14E+05	4.00E+03
SD01	63	27	3.55E+06	8.42E-01	1.17E+00	5.18E+05	3.20E+03
SD01	64	27	3.54E+06	8.40E-01	1.17E+00	5.22E+05	4.00E+03
SD01	65	820	3.73E+03	1.47E-03	6.16E-01	5.22E+05	2.16E+04
SD01	66	821	3.10E+03	1.22E-03	6.16E-01	5.22E+05	2.16E+04
SD01	67	824	1.68E+03	6.62E-04	6.16E-01	5.22E+05	2.16E+04
SD01	68	27	3.54E+06	8.41E-01	1.17E+00	5.26E+05	3.20E+03
SD01	69	27	3.54E+06	8.40E-01	1.17E+00	5.29E+05	4.00E+03
SD01	70	27	3.54E+06	8.41E-01	1.17E+00	5.33E+05	3.20E+03
SD01	71	27	3.54E+06	8.41E-01	1.17E+00	5.36E+05	4.00E+03
SD01	72	27	3.54E+06	8.40E-01	1.17E+00	5.40E+05	3.20E+03
SD01	73	27	3.54E+06	8.40E-01	1.17E+00	5.43E+05	4.00E+03
SD01	74	820	4.08E+03	1.59E-03	5.99E-01	5.43E+05	2.16E+04
SD01	75	821	3.38E+03	1.32E-03	6.00E-01	5.43E+05	2.16E+04
SD01	76	824	1.84E+03	7.17E-04	6.00E-01	5.43E+05	2.16E+04
SD01	77	27	3.54E+06	8.40E-01	1.17E+00	5.47E+05	3.20E+03
SD01	78	27	3.54E+06	8.41E-01	1.17E+00	5.50E+05	4.00E+03
SD01	79	27	3.54E+06	8.40E-01	1.17E+00	5.54E+05	3.20E+03
SD01	80	27	3.54E+06	8.41E-01	1.17E+00	5.58E+05	4.00E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD01	81	27	3.54E+06	8.40E-01	1.17E+00	5.62E+05	3.20E+03
SD01	82	27	3.54E+06	8.41E-01	1.17E+00	5.65E+05	4.00E+03
SD01	83	820	4.47E+03	1.73E-03	5.84E-01	5.65E+05	2.16E+04
SD01	84	821	3.70E+03	1.43E-03	5.84E-01	5.65E+05	2.16E+04
SD01	85	824	2.01E+03	7.78E-04	5.84E-01	5.65E+05	2.16E+04
SD01	86	27	3.54E+06	8.40E-01	1.17E+00	5.69E+05	3.20E+03
SD01	87	27	3.54E+06	8.40E-01	1.17E+00	5.72E+05	4.00E+03
SD01	88	27	3.54E+06	8.40E-01	1.17E+00	5.76E+05	3.20E+03
SD01	89	27	3.55E+06	8.41E-01	1.17E+00	5.79E+05	4.00E+03
SD01	90	27	3.54E+06	8.40E-01	1.17E+00	5.83E+05	3.20E+03
SD01	91	27	3.54E+06	8.40E-01	1.17E+00	5.86E+05	4.00E+03
SD01	92	820	4.87E+03	1.87E-03	5.70E-01	5.86E+05	2.16E+04
SD01	93	821	4.04E+03	1.55E-03	5.70E-01	5.86E+05	2.16E+04
SD01	94	824	2.19E+03	8.42E-04	5.70E-01	5.86E+05	2.16E+04
SD01	95	27	3.54E+06	8.40E-01	1.17E+00	5.90E+05	3.20E+03
SD01	96	27	3.55E+06	8.42E-01	1.17E+00	5.94E+05	4.00E+03
SD01	97	27	3.54E+06	8.40E-01	1.17E+00	5.98E+05	3.20E+03
SD01	98	27	3.54E+06	8.40E-01	1.17E+00	6.01E+05	4.00E+03
SD01	99	27	3.55E+06	8.42E-01	1.17E+00	6.05E+05	3.20E+03
SD01	100	27	3.54E+06	8.40E-01	1.17E+00	6.08E+05	4.00E+03
SD01	101	820	5.29E+03	2.02E-03	5.57E-01	6.08E+05	2.16E+04
SD01	102	821	4.39E+03	1.67E-03	5.57E-01	6.08E+05	2.16E+04
SD01	103	824	2.38E+03	9.07E-04	5.57E-01	6.08E+05	2.16E+04
SD01	104	27	3.55E+06	8.42E-01	1.17E+00	6.12E+05	3.20E+03
SD01	105	27	3.54E+06	8.40E-01	1.17E+00	6.15E+05	4.00E+03
SD01	106	27	3.55E+06	8.42E-01	1.17E+00	6.19E+05	3.20E+03
SD01	107	27	3.54E+06	8.40E-01	1.17E+00	6.22E+05	4.00E+03
SD01	108	27	3.55E+06	8.42E-01	1.17E+00	6.26E+05	3.20E+03
SD01	109	27	3.54E+06	8.41E-01	1.17E+00	6.30E+05	4.00E+03
SD01	110	820	5.73E+03	2.17E-03	5.45E-01	6.30E+05	2.16E+04
SD01	111	821	4.76E+03	1.80E-03	5.45E-01	6.30E+05	2.16E+04
SD01	112	824	2.58E+03	9.76E-04	5.45E-01	6.30E+05	2.16E+04
SD01	113	27	3.54E+06	8.40E-01	1.17E+00	6.34E+05	3.20E+03
SD01	114	27	3.54E+06	8.41E-01	1.17E+00	6.37E+05	4.00E+03
SD01	115	27	3.54E+06	8.41E-01	1.17E+00	6.41E+05	3.20E+03
SD01	116	27	3.54E+06	8.40E-01	1.17E+00	6.44E+05	4.00E+03
SD01	117	27	3.54E+06	8.41E-01	1.17E+00	6.48E+05	3.20E+03
SD01	118	27	3.54E+06	8.41E-01	1.17E+00	6.51E+05	4.00E+03
SD01	119	820	6.19E+03	2.32E-03	5.35E-01	6.51E+05	2.16E+04
SD01	120	821	5.13E+03	1.93E-03	5.35E-01	6.51E+05	2.16E+04

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD01	121	824	2.79E+03	1.05E-03	5.35E-01	6.51E+05	2.16E+04
SD01	122	27	3.53E+06	8.39E-01	1.17E+00	6.55E+05	3.20E+03
SD01	123	27	3.54E+06	8.41E-01	1.17E+00	6.58E+05	4.00E+03
SD01	124	27	3.54E+06	8.41E-01	1.17E+00	6.62E+05	3.20E+03
SD01	125	27	3.54E+06	8.41E-01	1.17E+00	6.66E+05	4.00E+03
SD01	126	27	3.54E+06	8.41E-01	1.17E+00	6.70E+05	3.20E+03
SD01	127	27	3.54E+06	8.41E-01	1.17E+00	6.73E+05	4.00E+03
SD01	128	820	6.66E+03	2.49E-03	5.25E-01	6.73E+05	2.16E+04
SD01	129	821	5.53E+03	2.06E-03	5.26E-01	6.73E+05	2.16E+04
SD01	130	824	3.00E+03	1.12E-03	5.26E-01	6.73E+05	2.16E+04
SD01	131	27	3.53E+06	8.39E-01	1.17E+00	6.77E+05	3.20E+03
SD01	132	27	3.54E+06	8.41E-01	1.17E+00	6.80E+05	4.00E+03
SD01	133	27	3.54E+06	8.41E-01	1.17E+00	6.84E+05	3.20E+03
SD01	134	27	3.54E+06	8.41E-01	1.17E+00	6.87E+05	4.00E+03
SD01	135	27	3.54E+06	8.41E-01	1.17E+00	6.91E+05	3.20E+03
SD01	136	27	3.54E+06	8.41E-01	1.17E+00	6.94E+05	4.00E+03
SD01	137	820	7.15E+03	2.65E-03	5.18E-01	6.94E+05	2.16E+04
SD01	138	821	5.93E+03	2.20E-03	5.18E-01	6.94E+05	2.16E+04
SD01	139	824	3.22E+03	1.19E-03	5.18E-01	6.94E+05	2.16E+04
SD01	140	27	3.54E+06	8.41E-01	1.17E+00	6.98E+05	3.20E+03
SD01	141	27	3.54E+06	8.41E-01	1.17E+00	7.02E+05	4.00E+03
SD01	142	27	3.54E+06	8.41E-01	1.17E+00	7.06E+05	3.20E+03
SD01	143	27	3.54E+06	8.41E-01	1.17E+00	7.09E+05	4.00E+03
SD01	144	27	3.54E+06	8.41E-01	1.17E+00	7.13E+05	3.20E+03
SD01	145	27	3.54E+06	8.41E-01	1.17E+00	7.16E+05	4.00E+03
SD01	146	820	7.69E+03	2.84E-03	5.12E-01	7.16E+05	2.16E+04
SD01	147	821	6.38E+03	2.35E-03	5.12E-01	7.16E+05	2.16E+04
SD01	148	824	3.46E+03	1.28E-03	5.12E-01	7.16E+05	2.16E+04
SD01	149	27	3.54E+06	8.41E-01	1.17E+00	7.20E+05	3.20E+03
SD01	150	27	3.54E+06	8.41E-01	1.17E+00	7.23E+05	4.00E+03
SD01	151	27	3.54E+06	8.41E-01	1.17E+00	7.27E+05	3.20E+03
SD01	152	27	3.54E+06	8.41E-01	1.17E+00	7.30E+05	4.00E+03
SD01	153	27	3.54E+06	8.41E-01	1.17E+00	7.34E+05	3.20E+03
SD01	154	27	3.54E+06	8.41E-01	1.17E+00	7.38E+05	4.00E+03
SD01	155	820	8.26E+03	3.03E-03	5.06E-01	7.38E+05	2.16E+04
SD01	156	821	6.85E+03	2.51E-03	5.06E-01	7.38E+05	2.16E+04
SD01	157	824	3.72E+03	1.36E-03	5.06E-01	7.38E+05	2.16E+04
SD01	158	27	3.54E+06	8.41E-01	1.17E+00	7.42E+05	3.20E+03
SD01	159	27	3.54E+06	8.41E-01	1.17E+00	7.45E+05	4.00E+03
SD01	160	27	3.54E+06	8.41E-01	1.17E+00	7.49E+05	3.20E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD01	161	27	3.54E+06	8.41E-01	1.17E+00	7.52E+05	4.00E+03
SD01	162	27	3.54E+06	8.41E-01	1.17E+00	7.56E+05	3.20E+03
SD01	163	27	3.54E+06	8.41E-01	1.17E+00	7.59E+05	4.00E+03
SD01	164	820	8.84E+03	3.23E-03	5.01E-01	7.59E+05	2.16E+04
SD01	165	821	7.33E+03	2.68E-03	5.01E-01	7.59E+05	2.16E+04
SD01	166	824	3.98E+03	1.45E-03	5.01E-01	7.59E+05	2.16E+04
SD01	167	27	3.54E+06	8.41E-01	1.17E+00	7.63E+05	3.20E+03
SD01	168	27	3.54E+06	8.41E-01	1.17E+00	7.66E+05	4.00E+03
SD01	169	27	3.54E+06	8.41E-01	1.17E+00	7.70E+05	3.20E+03
SD01	170	27	3.54E+06	8.41E-01	1.17E+00	7.74E+05	4.00E+03
SD01	171	27	3.54E+06	8.41E-01	1.17E+00	7.78E+05	3.20E+03
SD01	172	27	3.54E+06	8.41E-01	1.17E+00	7.81E+05	4.00E+03
SD01	173	820	9.43E+03	3.43E-03	4.97E-01	7.81E+05	2.16E+04
SD01	174	821	7.82E+03	2.84E-03	4.97E-01	7.81E+05	2.16E+04
SD01	175	824	4.25E+03	1.54E-03	4.97E-01	7.81E+05	2.16E+04
SD01	176	27	3.54E+06	8.41E-01	1.17E+00	7.85E+05	3.20E+03
SD01	177	27	3.54E+06	8.41E-01	1.17E+00	7.88E+05	4.00E+03
SD01	178	27	3.54E+06	8.41E-01	1.17E+00	7.92E+05	3.20E+03
SD01	179	27	3.54E+06	8.41E-01	1.17E+00	7.95E+05	4.00E+03
SD01	180	27	3.54E+06	8.41E-01	1.17E+00	7.99E+05	3.20E+03
SD01	181	27	3.54E+06	8.41E-01	1.17E+00	8.02E+05	4.00E+03
SD01	182	820	1.00E+04	3.64E-03	4.93E-01	8.02E+05	2.16E+04
SD01	183	821	8.32E+03	3.02E-03	4.93E-01	8.02E+05	2.16E+04
SD01	184	824	4.52E+03	1.64E-03	4.93E-01	8.02E+05	2.16E+04
SD01	185	27	3.54E+06	8.41E-01	1.17E+00	8.06E+05	3.20E+03
SD01	186	27	3.54E+06	8.41E-01	1.17E+00	8.10E+05	4.00E+03
SD01	187	27	3.54E+06	8.41E-01	1.17E+00	8.14E+05	3.20E+03
SD01	188	27	3.54E+06	8.41E-01	1.17E+00	8.17E+05	4.00E+03
SD01	189	27	3.54E+06	8.41E-01	1.17E+00	8.21E+05	3.20E+03
SD01	190	27	3.54E+06	8.41E-01	1.17E+00	8.24E+05	4.00E+03
SD01	191	820	1.07E+04	3.85E-03	4.89E-01	8.24E+05	2.16E+04
SD01	192	821	8.84E+03	3.19E-03	4.89E-01	8.24E+05	2.16E+04
SD01	193	824	4.80E+03	1.73E-03	4.89E-01	8.24E+05	2.16E+04
SD01	194	27	3.54E+06	8.42E-01	1.17E+00	8.28E+05	3.20E+03
SD01	195	27	3.55E+06	8.42E-01	1.17E+00	8.31E+05	4.00E+03
SD01	196	27	3.54E+06	8.42E-01	1.17E+00	8.35E+05	3.20E+03
SD01	197	27	3.55E+06	8.42E-01	1.17E+00	8.38E+05	4.00E+03
SD01	198	27	3.55E+06	8.42E-01	1.17E+00	8.42E+05	3.20E+03
SD01	199	27	3.55E+06	8.42E-01	1.17E+00	8.46E+05	4.00E+03
SD01	200	820	1.13E+04	4.06E-03	4.85E-01	8.46E+05	2.16E+04

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD01	201	821	9.36E+03	3.37E-03	4.85E-01	8.46E+05	2.16E+04
SD01	202	824	5.08E+03	1.83E-03	4.85E-01	8.46E+05	2.16E+04
SD01	203	27	3.55E+06	8.42E-01	1.17E+00	8.50E+05	3.20E+03
SD01	204	27	3.55E+06	8.42E-01	1.17E+00	8.53E+05	4.00E+03
SD01	205	27	3.55E+06	8.42E-01	1.17E+00	8.57E+05	3.20E+03
SD01	206	27	3.55E+06	8.42E-01	1.17E+00	8.60E+05	4.00E+03
SD01	207	27	3.55E+06	8.42E-01	1.17E+00	8.64E+05	3.20E+03
SD01	208	27	3.55E+06	8.42E-01	1.17E+00	8.67E+05	4.00E+03
SD01	209	820	1.19E+04	4.28E-03	4.82E-01	8.67E+05	2.16E+04
SD01	210	821	9.90E+03	3.55E-03	4.82E-01	8.67E+05	2.16E+04
SD01	211	824	5.38E+03	1.93E-03	4.82E-01	8.67E+05	2.16E+04
SD01	212	27	3.55E+06	8.42E-01	1.17E+00	8.71E+05	3.20E+03
SD01	213	27	3.55E+06	8.42E-01	1.17E+00	8.74E+05	4.00E+03
SD01	214	27	3.55E+06	8.42E-01	1.17E+00	8.78E+05	3.20E+03
SD01	215	27	3.55E+06	8.42E-01	1.17E+00	8.82E+05	4.00E+03
SD01	216	27	3.55E+06	8.42E-01	1.17E+00	8.86E+05	3.20E+03
SD01	217	27	3.55E+06	8.42E-01	1.17E+00	8.89E+05	4.00E+03
SD01	218	820	1.24E+04	4.45E-03	4.79E-01	8.89E+05	1.12E+04
SD01	219	821	1.03E+04	3.69E-03	4.79E-01	8.89E+05	1.12E+04
SD01	220	824	5.60E+03	2.01E-03	4.79E-01	8.89E+05	1.12E+04
SD01	221	27	3.55E+06	8.42E-01	1.17E+00	8.93E+05	3.20E+03
SD01	222	27	8.32E+06	1.98E+00	1.17E+00	8.96E+05	4.00E+03
SD01-2	1	820	2.79E+03	7.06E-04	8.51E-01	3.49E+05	2.15E+04
SD01-2	2	821	2.32E+03	5.85E-04	8.51E-01	3.49E+05	2.15E+04
SD01-2	3	824	1.25E+03	3.17E-04	8.51E-01	3.49E+05	2.15E+04
SD01-2	4	820	3.15E+03	8.60E-04	7.48E-01	3.71E+05	2.15E+04
SD01-2	5	821	2.64E+03	7.23E-04	7.62E-01	3.71E+05	2.15E+04
SD01-2	6	824	1.43E+03	3.92E-04	7.62E-01	3.71E+05	2.15E+04
SD01-2	7	820	3.32E+03	9.80E-04	7.21E-01	3.92E+05	2.20E+04
SD01-2	8	821	2.75E+03	8.13E-04	7.21E-01	3.92E+05	2.20E+04
SD01-2	9	824	1.49E+03	4.40E-04	7.21E-01	3.92E+05	2.20E+04
SD01-2	10	820	3.62E+03	1.08E-03	6.84E-01	4.14E+05	2.15E+04
SD01-2	11	821	3.00E+03	8.93E-04	6.84E-01	4.14E+05	2.15E+04
SD01-2	12	824	1.63E+03	4.84E-04	6.84E-01	4.14E+05	2.15E+04
SD01-2	13	844	1.35E+06	3.98E-01	6.46E-01	4.21E+05	3.50E+03
SD01-2	14	844	3.31E+06	9.75E-01	6.41E-01	4.25E+05	3.50E+03
SD01-2	15	844	3.01E+06	8.88E-01	6.35E-01	4.28E+05	4.00E+03
SD01-2	16	844	3.21E+06	9.47E-01	6.28E-01	4.32E+05	3.50E+03
SD01-2	17	820	3.52E+03	1.06E-03	6.48E-01	4.36E+05	2.15E+04
SD01-2	18	821	2.92E+03	8.77E-04	6.48E-01	4.36E+05	2.15E+04

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD01-2	19	844	3.06E+06	9.05E-01	6.22E-01	4.36E+05	3.50E+03
SD01-2	20	844	2.94E+06	8.73E-01	6.18E-01	4.39E+05	3.50E+03
SD01-2	21	844	2.92E+06	8.69E-01	6.14E-01	4.43E+05	3.50E+03
SD01-2	22	844	2.02E+06	6.00E-01	6.10E-01	4.46E+05	4.00E+03
SD01-2	23	844	1.65E+06	4.91E-01	6.05E-01	4.50E+05	3.50E+03
SD01-2	24	844	1.58E+06	4.72E-01	6.02E-01	4.54E+05	3.50E+03
SD01-2	25	820	3.20E+03	1.02E-03	5.97E-01	4.57E+05	2.15E+04
SD01-2	26	821	2.67E+03	8.54E-04	6.05E-01	4.57E+05	2.15E+04
SD01-2	27	844	1.71E+06	5.09E-01	5.98E-01	4.57E+05	3.50E+03
SD01-2	28	844	1.74E+06	5.19E-01	5.94E-01	4.61E+05	3.50E+03
SD01-2	29	844	1.76E+06	5.27E-01	5.89E-01	4.64E+05	4.00E+03
SD01-2	30	844	1.80E+06	5.37E-01	5.85E-01	4.68E+05	3.50E+03
SD01-2	31	844	9.79E+06	3.80E+00	4.86E-01	4.72E+05	3.50E+03
SD01-2	32	820	2.34E+03	9.87E-04	5.88E-01	4.79E+05	2.13E+04
SD01-2	33	821	1.94E+03	8.18E-04	5.88E-01	4.79E+05	2.13E+04
SD01-2	34	844	2.17E+05	9.08E-02	5.74E-01	4.82E+05	4.00E+03
SD01-2	35	844	7.60E+05	3.17E-01	5.67E-01	4.86E+05	3.50E+03
SD01-2	36	844	9.07E+05	3.77E-01	5.63E-01	4.90E+05	3.50E+03
SD01-2	37	844	1.07E+06	4.44E-01	5.61E-01	4.93E+05	3.60E+03
SD01-2	38	844	1.47E+06	6.08E-01	5.58E-01	4.97E+05	3.20E+03
SD01-2	39	820	2.40E+03	9.95E-04	5.74E-01	5.00E+05	2.16E+04
SD01-2	40	821	1.99E+03	8.25E-04	5.75E-01	5.00E+05	2.16E+04
SD01-2	41	844	1.55E+06	6.38E-01	5.55E-01	5.00E+05	4.00E+03
SD01-2	42	844	1.60E+06	6.56E-01	5.52E-01	5.04E+05	4.00E+03
SD01-2	43	844	1.64E+06	6.70E-01	5.48E-01	5.08E+05	3.20E+03
SD01-2	44	844	1.68E+06	6.81E-01	5.45E-01	5.11E+05	4.00E+03
SD01-2	45	844	1.71E+06	6.90E-01	5.42E-01	5.15E+05	3.20E+03
SD01-2	46	844	1.73E+06	6.97E-01	5.39E-01	5.18E+05	4.00E+03
SD01-2	47	820	2.42E+03	9.79E-04	5.55E-01	5.22E+05	2.16E+04
SD01-2	48	821	2.00E+03	8.11E-04	5.55E-01	5.22E+05	2.16E+04
SD01-2	49	824	1.09E+03	4.40E-04	5.55E-01	5.22E+05	2.16E+04
SD01-2	50	844	1.75E+06	7.03E-01	5.36E-01	5.22E+05	3.20E+03
SD01-2	51	844	1.77E+06	7.08E-01	5.33E-01	5.26E+05	3.20E+03
SD01-2	52	844	1.79E+06	7.14E-01	5.30E-01	5.29E+05	4.00E+03
SD01-2	53	844	1.81E+06	7.19E-01	5.27E-01	5.33E+05	3.20E+03
SD01-2	54	844	1.83E+06	7.24E-01	5.24E-01	5.36E+05	4.00E+03
SD01-2	55	844	1.85E+06	7.28E-01	5.21E-01	5.40E+05	3.20E+03
SD01-2	56	820	2.43E+03	9.62E-04	5.37E-01	5.43E+05	2.16E+04
SD01-2	57	821	2.01E+03	7.98E-04	5.37E-01	5.43E+05	2.16E+04
SD01-2	58	824	1.09E+03	4.32E-04	5.37E-01	5.43E+05	2.16E+04

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD01-2	59	844	1.86E+06	7.32E-01	5.19E-01	5.43E+05	4.00E+03
SD01-2	60	844	1.88E+06	7.36E-01	5.16E-01	5.47E+05	3.20E+03
SD01-2	61	844	1.90E+06	7.40E-01	5.13E-01	5.50E+05	4.00E+03
SD01-2	62	844	1.91E+06	7.44E-01	5.11E-01	5.54E+05	3.20E+03
SD01-2	63	844	1.93E+06	7.47E-01	5.08E-01	5.58E+05	4.00E+03
SD01-2	64	844	1.94E+06	7.51E-01	5.05E-01	5.62E+05	4.00E+03
SD01-2	65	820	2.44E+03	9.48E-04	5.21E-01	5.65E+05	2.16E+04
SD01-2	66	821	2.02E+03	7.86E-04	5.21E-01	5.65E+05	2.16E+04
SD01-2	67	844	1.96E+06	7.54E-01	5.03E-01	5.66E+05	3.20E+03
SD01-2	68	844	1.97E+06	7.56E-01	5.01E-01	5.69E+05	3.20E+03
SD01-2	69	844	1.99E+06	7.60E-01	4.98E-01	5.72E+05	4.00E+03
SD01-2	70	844	2.00E+06	7.62E-01	4.96E-01	5.76E+05	4.00E+03
SD01-2	71	844	2.02E+06	7.65E-01	4.94E-01	5.80E+05	3.20E+03
SD01-2	72	844	2.03E+06	7.68E-01	4.92E-01	5.83E+05	4.00E+03
SD01-2	73	820	2.45E+03	9.35E-04	5.07E-01	5.86E+05	2.16E+04
SD01-2	74	821	2.03E+03	7.75E-04	5.07E-01	5.86E+05	2.16E+04
SD01-2	75	844	2.04E+06	7.70E-01	4.89E-01	5.87E+05	3.20E+03
SD01-2	76	844	2.05E+06	7.73E-01	4.88E-01	5.90E+05	3.20E+03
SD01-2	77	844	2.07E+06	7.75E-01	4.86E-01	5.94E+05	4.00E+03
SD01-2	78	844	2.08E+06	7.77E-01	4.83E-01	5.98E+05	4.00E+03
SD01-2	79	844	2.09E+06	7.80E-01	4.81E-01	6.02E+05	3.20E+03
SD01-2	80	844	2.10E+06	7.82E-01	4.80E-01	6.05E+05	3.20E+03
SD01-2	81	820	2.47E+03	9.24E-04	4.95E-01	6.08E+05	2.16E+04
SD01-2	82	821	2.04E+03	7.65E-04	4.95E-01	6.08E+05	2.16E+04
SD01-2	83	844	2.11E+06	7.84E-01	4.78E-01	6.08E+05	4.00E+03
SD01-2	84	844	2.13E+06	7.86E-01	4.76E-01	6.12E+05	4.00E+03
SD01-2	85	844	2.14E+06	7.89E-01	4.74E-01	6.16E+05	3.20E+03
SD01-2	86	844	2.15E+06	7.91E-01	4.73E-01	6.19E+05	4.00E+03
SD01-2	87	844	2.16E+06	7.93E-01	4.71E-01	6.23E+05	3.20E+03
SD01-2	88	844	2.17E+06	7.95E-01	4.70E-01	6.26E+05	3.20E+03
SD01-2	89	820	2.48E+03	9.14E-04	4.84E-01	6.30E+05	2.16E+04
SD01-2	90	844	2.18E+06	7.97E-01	4.68E-01	6.30E+05	4.00E+03
SD01-2	91	844	2.19E+06	8.00E-01	4.66E-01	6.34E+05	4.00E+03
SD01-2	92	844	2.21E+06	8.02E-01	4.65E-01	6.38E+05	3.20E+03
SD01-2	93	844	2.22E+06	8.04E-01	4.64E-01	6.41E+05	4.00E+03
SD01-2	94	844	2.23E+06	8.06E-01	4.62E-01	6.45E+05	3.20E+03
SD01-2	95	844	2.24E+06	8.08E-01	4.61E-01	6.48E+05	4.00E+03
SD01-2	96	844	2.25E+06	8.10E-01	4.60E-01	6.52E+05	3.20E+03
SD01-2	97	844	2.26E+06	8.12E-01	4.59E-01	6.55E+05	4.00E+03
SD01-2	98	844	2.27E+06	8.14E-01	4.58E-01	6.59E+05	3.20E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD01-2	99	844	2.28E+06	8.16E-01	4.57E-01	6.62E+05	3.20E+03
SD01-2	100	844	2.29E+06	8.17E-01	4.56E-01	6.66E+05	4.00E+03
SD01-2	101	844	2.30E+06	8.19E-01	4.55E-01	6.70E+05	3.20E+03
SD01-2	102	820	2.50E+03	8.99E-04	4.69E-01	6.73E+05	2.16E+04
SD01-2	103	821	2.07E+03	7.45E-04	4.69E-01	6.73E+05	2.16E+04
SD01-2	104	844	2.30E+06	8.21E-01	4.54E-01	6.73E+05	4.00E+03
SD01-2	105	844	2.31E+06	8.23E-01	4.53E-01	6.77E+05	3.20E+03
SD01-2	106	844	2.38E+06	8.45E-01	4.53E-01	6.80E+05	4.00E+03
SD01-2	107	844	2.33E+06	8.26E-01	4.53E-01	6.84E+05	3.20E+03
SD01-2	108	844	2.31E+06	8.20E-01	4.52E-01	6.87E+05	4.00E+03
SD01-2	109	844	2.45E+06	8.65E-01	4.51E-01	6.91E+05	3.20E+03
SD01-2	110	820	2.51E+03	8.94E-04	4.64E-01	6.94E+05	2.16E+04
SD01-2	111	821	2.08E+03	7.41E-04	4.64E-01	6.94E+05	2.16E+04
SD01-2	112	824	1.13E+03	4.01E-04	4.64E-01	6.94E+05	2.16E+04
SD01-2	113	844	2.45E+06	8.66E-01	4.51E-01	6.94E+05	4.00E+03
SD01-2	114	844	2.51E+06	8.86E-01	4.50E-01	6.98E+05	3.20E+03
SD01-2	115	844	2.53E+06	8.91E-01	4.51E-01	7.02E+05	4.00E+03
SD01-2	116	844	2.47E+06	8.69E-01	4.51E-01	7.06E+05	4.00E+03
SD01-2	117	844	2.54E+06	8.94E-01	4.51E-01	7.10E+05	3.20E+03
SD01-2	118	844	2.55E+06	8.96E-01	4.52E-01	7.13E+05	3.20E+03
SD01-2	119	820	2.53E+03	8.94E-04	4.64E-01	7.16E+05	2.16E+04
SD01-2	120	821	2.09E+03	7.41E-04	4.64E-01	7.16E+05	2.16E+04
SD01-2	121	844	2.58E+06	9.04E-01	4.52E-01	7.16E+05	4.00E+03
SD01-2	122	844	2.65E+06	9.28E-01	4.51E-01	7.20E+05	3.20E+03
SD01-2	123	844	2.69E+06	9.43E-01	4.51E-01	7.23E+05	4.00E+03
SD01-2	124	844	2.60E+06	9.08E-01	4.51E-01	7.27E+05	4.00E+03
SD01-2	125	844	2.62E+06	9.14E-01	4.52E-01	7.31E+05	3.20E+03
SD01-2	126	844	2.65E+06	9.26E-01	4.52E-01	7.34E+05	3.20E+03
SD01-2	127	820	2.54E+03	8.93E-04	4.63E-01	7.38E+05	2.16E+04
SD01-2	128	821	2.10E+03	7.40E-04	4.63E-01	7.38E+05	2.16E+04
SD01-2	129	844	2.67E+06	9.32E-01	4.52E-01	7.38E+05	4.00E+03
SD01-2	130	844	2.69E+06	9.36E-01	4.52E-01	7.42E+05	4.00E+03
SD01-2	131	844	2.77E+06	9.64E-01	4.51E-01	7.46E+05	3.20E+03
SD01-2	132	844	2.63E+06	9.18E-01	4.53E-01	7.49E+05	3.20E+03
SD01-2	133	844	1.86E+06	6.47E-01	4.51E-01	7.52E+05	4.00E+03
SD01-2	134	844	1.22E+06	4.24E-01	4.48E-01	7.56E+05	4.00E+03
SD01-2	135	820	2.54E+03	8.86E-04	4.59E-01	7.59E+05	2.16E+04
SD01-2	136	821	2.10E+03	7.34E-04	4.59E-01	7.59E+05	2.16E+04
SD01-2	137	824	1.14E+03	3.98E-04	4.59E-01	7.59E+05	2.16E+04
SD01-2	138	844	1.21E+06	4.18E-01	4.47E-01	7.60E+05	3.20E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD01-2	139	844	1.21E+06	4.18E-01	4.46E-01	7.63E+05	4.00E+03
SD01-2	140	844	1.21E+06	4.20E-01	4.46E-01	7.67E+05	3.20E+03
SD01-2	141	844	1.22E+06	4.20E-01	4.45E-01	7.70E+05	4.00E+03
SD01-2	142	844	1.22E+06	4.20E-01	4.44E-01	7.74E+05	3.20E+03
SD01-2	143	844	1.23E+06	4.23E-01	4.44E-01	7.78E+05	3.20E+03
SD01-2	144	820	2.54E+03	8.82E-04	4.55E-01	7.81E+05	2.16E+04
SD01-2	145	821	2.11E+03	7.31E-04	4.55E-01	7.81E+05	2.16E+04
SD01-2	146	824	1.14E+03	3.96E-04	4.55E-01	7.81E+05	2.16E+04
SD01-2	147	844	1.25E+06	4.29E-01	4.43E-01	7.81E+05	4.00E+03
SD01-2	148	844	1.24E+06	4.25E-01	4.43E-01	7.85E+05	3.20E+03
SD01-2	149	844	1.24E+06	4.27E-01	4.42E-01	7.88E+05	4.00E+03
SD01-2	150	844	1.22E+06	4.19E-01	4.42E-01	7.92E+05	4.00E+03
SD01-2	151	844	1.02E+06	3.48E-01	4.41E-01	7.96E+05	3.20E+03
SD01-2	152	844	8.70E+05	2.98E-01	4.40E-01	7.99E+05	4.00E+03
SD01-2	153	820	2.54E+03	8.76E-04	4.50E-01	8.02E+05	2.16E+04
SD01-2	154	821	2.11E+03	7.26E-04	4.51E-01	8.02E+05	2.16E+04
SD01-2	155	824	1.14E+03	3.93E-04	4.51E-01	8.02E+05	2.16E+04
SD01-2	156	844	4.10E+05	1.41E-01	4.38E-01	8.03E+05	3.20E+03
SD01-2	157	844	4.83E+05	1.66E-01	4.52E-01	8.06E+05	4.00E+03
SD01-2	158	844	3.29E+05	1.13E-01	4.51E-01	8.10E+05	3.20E+03
SD01-2	159	844	3.81E+05	1.30E-01	4.36E-01	8.14E+05	3.20E+03
SD01-2	160	844	3.82E+05	1.31E-01	4.35E-01	8.17E+05	4.00E+03
SD01-2	161	844	3.81E+05	1.30E-01	4.35E-01	8.21E+05	4.00E+03
SD01-2	162	820	2.54E+03	8.71E-04	4.46E-01	8.24E+05	2.16E+04
SD01-2	163	821	2.11E+03	7.22E-04	4.46E-01	8.24E+05	2.16E+04
SD01-2	164	824	1.14E+03	3.91E-04	4.46E-01	8.24E+05	2.16E+04
SD01-2	165	844	3.79E+05	1.29E-01	4.33E-01	8.25E+05	3.20E+03
SD01-2	166	844	3.78E+05	1.29E-01	4.32E-01	8.28E+05	3.20E+03
SD01-2	167	844	4.75E+05	1.61E-01	4.30E-01	8.31E+05	4.00E+03
SD01-2	168	844	2.86E+05	9.72E-02	4.29E-01	8.35E+05	3.20E+03
SD01-2	169	844	3.73E+05	1.27E-01	4.29E-01	8.38E+05	4.00E+03
SD01-2	170	844	3.65E+05	1.24E-01	4.28E-01	8.42E+05	3.20E+03
SD01-2	171	820	2.54E+03	8.66E-04	4.41E-01	8.46E+05	2.16E+04
SD01-2	172	821	2.11E+03	7.18E-04	4.42E-01	8.46E+05	2.16E+04
SD01-2	173	824	1.14E+03	3.89E-04	4.42E-01	8.46E+05	2.16E+04
SD01-2	174	844	3.66E+05	1.24E-01	4.29E-01	8.46E+05	4.00E+03
SD01-2	175	844	3.66E+05	1.24E-01	4.28E-01	8.50E+05	4.00E+03
SD01-2	176	844	3.66E+05	1.24E-01	4.28E-01	8.54E+05	3.20E+03
SD01-2	177	844	3.64E+05	1.23E-01	4.26E-01	8.57E+05	3.20E+03
SD01-2	178	844	3.87E+05	1.30E-01	4.26E-01	8.60E+05	4.00E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD01-2	179	844	3.55E+05	1.20E-01	4.27E-01	8.64E+05	4.00E+03
SD01-2	180	820	2.54E+03	8.62E-04	4.38E-01	8.67E+05	2.16E+04
SD01-2	181	821	2.11E+03	7.14E-04	4.38E-01	8.67E+05	2.16E+04
SD01-2	182	824	1.14E+03	3.87E-04	4.38E-01	8.67E+05	2.16E+04
SD01-2	183	844	3.59E+05	1.21E-01	4.26E-01	8.68E+05	3.20E+03
SD01-2	184	844	3.60E+05	1.21E-01	4.25E-01	8.71E+05	3.20E+03
SD01-2	185	844	3.61E+05	1.21E-01	4.24E-01	8.74E+05	4.00E+03
SD01-2	186	844	3.61E+05	1.21E-01	4.24E-01	8.78E+05	3.20E+03
SD01-2	187	844	3.62E+05	1.22E-01	4.23E-01	8.82E+05	4.00E+03
SD01-2	188	844	4.56E+05	1.53E-01	4.22E-01	8.86E+05	3.20E+03
SD01-2	189	844	3.66E+05	1.23E-01	4.42E-01	8.89E+05	4.00E+03
SD01-2	190	844	3.50E+05	1.17E-01	4.20E-01	8.93E+05	3.20E+03
SD01-2	191	844	3.56E+05	1.19E-01	4.20E-01	8.96E+05	4.00E+03
SD01-8	1	820	2.80E+03	7.07E-04	8.52E-01	3.50E+05	2.15E+04
SD01-8	2	821	2.32E+03	5.86E-04	8.52E-01	3.50E+05	2.15E+04
SD01-8	3	824	1.26E+03	3.17E-04	8.52E-01	3.50E+05	2.15E+04
SD01-8	4	820	3.18E+03	8.47E-04	7.67E-01	3.71E+05	2.15E+04
SD01-8	5	821	2.65E+03	7.10E-04	7.80E-01	3.71E+05	2.15E+04
SD01-8	6	824	1.44E+03	3.85E-04	7.80E-01	3.71E+05	2.15E+04
SD01-8	7	820	3.00E+03	8.60E-04	7.87E-01	3.93E+05	2.20E+04
SD01-8	8	821	2.49E+03	7.13E-04	7.87E-01	3.93E+05	2.20E+04
SD01-8	9	824	1.35E+03	3.86E-04	7.87E-01	3.93E+05	2.20E+04
SD01-8	10	820	3.02E+03	8.61E-04	7.84E-01	4.15E+05	2.15E+04
SD01-8	11	821	2.50E+03	7.13E-04	7.84E-01	4.15E+05	2.15E+04
SD01-8	12	820	2.39E+03	8.87E-04	7.53E-01	4.36E+05	2.15E+04
SD01-8	13	821	1.99E+03	7.42E-04	7.61E-01	4.36E+05	2.15E+04
SD01-8	14	824	1.08E+03	4.03E-04	7.62E-01	4.36E+05	2.15E+04
SD01-8	15	820	2.16E+03	8.58E-04	7.84E-01	4.58E+05	2.15E+04
SD01-8	16	821	1.79E+03	7.12E-04	7.84E-01	4.58E+05	2.15E+04
SD01-8	17	820	2.23E+03	8.80E-04	7.68E-01	4.79E+05	2.16E+04
SD01-8	18	821	1.85E+03	7.29E-04	7.68E-01	4.79E+05	2.16E+04
SD01-8	19	820	2.55E+03	9.92E-04	7.18E-01	5.01E+05	2.16E+04
SD01-8	20	821	2.11E+03	8.23E-04	7.18E-01	5.01E+05	2.16E+04
SD01-8	21	820	2.25E+03	8.62E-04	6.73E-01	5.22E+05	2.16E+04
SD01-8	22	821	1.86E+03	7.14E-04	6.72E-01	5.22E+05	2.16E+04
SD01-8	23	844	1.04E+07	3.89E+00	6.08E-01	5.32E+05	4.00E+03
SD01-8	24	844	2.83E+07	1.08E+01	6.47E-01	5.36E+05	3.20E+03
SD01-8	25	844	1.98E+07	7.52E+00	6.44E-01	5.39E+05	4.00E+03
SD01-8	26	844	9.59E+06	3.65E+00	6.45E-01	5.43E+05	3.20E+03
SD01-8	27	844	4.33E+06	1.65E+00	6.46E-01	5.46E+05	4.00E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD01-8	28	844	3.04E+06	1.16E+00	6.42E-01	5.50E+05	3.20E+03
SD01-8	29	844	2.74E+06	1.04E+00	6.36E-01	5.54E+05	4.00E+03
SD01-8	30	844	2.57E+06	9.73E-01	6.31E-01	5.58E+05	3.20E+03
SD01-8	31	844	2.47E+06	9.32E-01	6.26E-01	5.61E+05	4.00E+03
SD01-8	32	844	2.39E+06	9.02E-01	6.21E-01	5.65E+05	3.20E+03
SD01-8	33	844	2.33E+06	8.78E-01	6.16E-01	5.68E+05	4.00E+03
SD01-8	34	844	2.29E+06	8.61E-01	6.11E-01	5.72E+05	3.20E+03
SD01-8	35	844	2.24E+06	8.41E-01	6.07E-01	5.75E+05	4.00E+03
SD01-8	36	844	2.21E+06	8.28E-01	6.03E-01	5.79E+05	3.20E+03
SD01-8	37	844	2.18E+06	8.15E-01	5.99E-01	5.82E+05	4.00E+03
SD01-8	38	844	2.16E+06	8.05E-01	5.95E-01	5.86E+05	3.20E+03
SD01-8	39	844	2.13E+06	7.94E-01	5.91E-01	5.90E+05	4.00E+03
SD01-8	40	844	2.11E+06	7.83E-01	5.87E-01	5.94E+05	3.20E+03
SD01-8	41	844	2.08E+06	7.73E-01	5.84E-01	5.97E+05	4.00E+03
SD01-8	42	844	2.06E+06	7.65E-01	5.80E-01	6.01E+05	3.20E+03
SD01-8	43	844	2.04E+06	7.57E-01	5.77E-01	6.04E+05	4.00E+03
SD01-8	44	844	2.03E+06	7.50E-01	5.74E-01	6.08E+05	3.20E+03
SD01-8	45	844	2.01E+06	7.44E-01	5.71E-01	6.11E+05	4.00E+03
SD01-8	46	844	2.00E+06	7.38E-01	5.68E-01	6.15E+05	3.20E+03
SD01-8	47	844	1.99E+06	7.33E-01	5.65E-01	6.18E+05	4.00E+03
SD01-8	48	844	1.98E+06	7.29E-01	5.63E-01	6.22E+05	3.20E+03
SD01-8	49	844	1.97E+06	7.25E-01	5.60E-01	6.26E+05	4.00E+03
SD01-8	50	844	1.97E+06	7.22E-01	5.58E-01	6.30E+05	3.20E+03
SD01-8	51	844	1.96E+06	7.19E-01	5.56E-01	6.33E+05	4.00E+03
SD01-8	52	844	1.96E+06	7.17E-01	5.53E-01	6.37E+05	3.20E+03
SD01-8	53	844	1.95E+06	7.15E-01	5.51E-01	6.40E+05	4.00E+03
SD01-8	54	844	1.95E+06	7.13E-01	5.49E-01	6.44E+05	3.20E+03
SD01-8	55	844	1.95E+06	7.11E-01	5.48E-01	6.47E+05	4.00E+03
SD01-8	56	844	1.95E+06	7.10E-01	5.46E-01	6.51E+05	3.20E+03
SD01-8	57	844	1.95E+06	7.09E-01	5.44E-01	6.54E+05	4.00E+03
SD01-8	58	844	1.95E+06	7.09E-01	5.43E-01	6.58E+05	3.20E+03
SD01-8	59	844	1.95E+06	7.09E-01	5.41E-01	6.62E+05	4.00E+03
SD01-8	60	844	1.95E+06	7.08E-01	5.40E-01	6.66E+05	3.20E+03
SD01-8	61	844	1.95E+06	7.09E-01	5.39E-01	6.69E+05	4.00E+03
SD01-8	62	844	1.95E+06	7.09E-01	5.37E-01	6.73E+05	3.20E+03
SD01-8	63	844	1.93E+06	7.01E-01	5.36E-01	6.76E+05	3.20E+03
SD01-8	64	844	1.93E+06	7.01E-01	5.35E-01	6.79E+05	4.00E+03
SD01-8	65	844	1.93E+06	7.02E-01	5.34E-01	6.83E+05	4.00E+03
SD01-8	66	844	1.94E+06	7.03E-01	5.33E-01	6.87E+05	3.20E+03
SD01-8	67	844	1.94E+06	7.04E-01	5.33E-01	6.90E+05	4.00E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD01-8	68	844	1.94E+06	7.05E-01	5.32E-01	6.94E+05	3.20E+03
SD01-8	69	844	1.95E+06	7.06E-01	5.31E-01	6.98E+05	4.00E+03
SD01-8	70	844	1.95E+06	7.07E-01	5.31E-01	7.02E+05	3.20E+03
SD01-8	71	844	1.96E+06	7.08E-01	5.30E-01	7.05E+05	4.00E+03
SD01-8	72	844	1.96E+06	7.09E-01	5.30E-01	7.09E+05	3.20E+03
SD01-8	73	844	1.96E+06	7.10E-01	5.30E-01	7.12E+05	4.00E+03
SD01-8	74	844	1.97E+06	7.11E-01	5.30E-01	7.16E+05	3.20E+03
SD01-8	75	844	1.97E+06	7.12E-01	5.30E-01	7.19E+05	4.00E+03
SD01-8	76	844	1.97E+06	7.13E-01	5.30E-01	7.23E+05	3.20E+03
SD01-8	77	844	1.98E+06	7.15E-01	5.31E-01	7.26E+05	3.20E+03
SD01-8	78	844	2.00E+06	7.21E-01	5.31E-01	7.30E+05	4.00E+03
SD01-8	79	844	2.06E+06	7.43E-01	5.32E-01	7.34E+05	4.00E+03
SD01-8	80	844	2.07E+06	7.49E-01	5.34E-01	7.38E+05	3.20E+03
SD01-8	81	844	2.15E+06	7.75E-01	5.34E-01	7.41E+05	4.00E+03
SD01-8	82	844	2.19E+06	7.90E-01	5.35E-01	7.45E+05	3.20E+03
SD01-8	83	844	2.20E+06	7.93E-01	5.35E-01	7.48E+05	4.00E+03
SD01-8	84	844	2.24E+06	8.10E-01	5.36E-01	7.52E+05	3.20E+03
SD01-8	85	844	2.26E+06	8.17E-01	5.36E-01	7.55E+05	4.00E+03
SD01-8	86	844	2.24E+06	8.10E-01	5.36E-01	7.59E+05	3.20E+03
SD01-8	87	844	2.24E+06	8.08E-01	5.39E-01	7.62E+05	4.00E+03
SD01-8	88	844	2.25E+06	8.14E-01	5.40E-01	7.66E+05	3.20E+03
SD01-8	89	844	2.27E+06	8.23E-01	5.42E-01	7.70E+05	4.00E+03
SD01-8	90	844	2.29E+06	8.28E-01	5.43E-01	7.74E+05	3.20E+03
SD01-8	91	844	2.30E+06	8.31E-01	5.44E-01	7.77E+05	4.00E+03
SD01-8	92	844	2.31E+06	8.36E-01	5.46E-01	7.81E+05	3.20E+03
SD01-8	93	844	2.36E+06	8.53E-01	5.45E-01	7.84E+05	4.00E+03
SD01-8	94	844	2.33E+06	8.45E-01	5.47E-01	7.88E+05	3.20E+03
SD01-8	95	844	2.35E+06	8.51E-01	5.48E-01	7.91E+05	4.00E+03
SD01-8	96	844	2.36E+06	8.56E-01	5.49E-01	7.95E+05	3.20E+03
SD01-8	97	844	2.38E+06	8.63E-01	5.50E-01	7.98E+05	4.00E+03
SD01-8	98	844	2.39E+06	8.67E-01	5.51E-01	8.02E+05	3.20E+03
SD01-8	99	844	2.37E+06	8.60E-01	5.52E-01	8.06E+05	4.00E+03
SD01-8	100	844	2.38E+06	8.63E-01	5.53E-01	8.10E+05	3.20E+03
SD01-8	101	844	2.43E+06	8.80E-01	5.52E-01	8.13E+05	4.00E+03
SD01-8	102	844	2.40E+06	8.71E-01	5.53E-01	8.17E+05	3.20E+03
SD01-8	103	844	2.48E+06	8.97E-01	5.52E-01	8.20E+05	4.00E+03
SD01-8	104	844	2.48E+06	8.98E-01	5.51E-01	8.24E+05	3.20E+03
SD01-8	105	844	2.46E+06	8.93E-01	5.51E-01	8.27E+05	4.00E+03
SD01-8	106	844	2.45E+06	8.88E-01	5.52E-01	8.31E+05	3.20E+03
SD01-8	107	844	2.50E+06	9.07E-01	5.51E-01	8.34E+05	4.00E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD01-8	108	844	2.47E+06	8.96E-01	5.52E-01	8.38E+05	3.20E+03
SD01-8	109	844	2.49E+06	9.05E-01	5.53E-01	8.42E+05	4.00E+03
SD01-8	110	844	2.50E+06	9.08E-01	5.53E-01	8.46E+05	3.20E+03
SD01-8	111	844	2.51E+06	9.09E-01	5.54E-01	8.49E+05	4.00E+03
SD01-8	112	844	2.55E+06	9.24E-01	5.53E-01	8.53E+05	3.20E+03
SD01-8	113	844	2.67E+06	9.69E-01	5.52E-01	8.56E+05	4.00E+03
SD01-8	114	844	2.62E+06	9.53E-01	5.53E-01	8.60E+05	3.20E+03
SD01-8	115	844	2.64E+06	9.60E-01	5.53E-01	8.63E+05	4.00E+03
SD01-8	116	844	2.69E+06	9.78E-01	5.52E-01	8.67E+05	3.20E+03
SD01-8	117	844	2.70E+06	9.79E-01	5.52E-01	8.70E+05	4.00E+03
SD01-8	118	844	2.67E+06	9.68E-01	5.52E-01	8.74E+05	3.20E+03
SD01-8	119	844	2.67E+06	9.70E-01	5.53E-01	8.78E+05	4.00E+03
SD01-8	120	844	2.69E+06	9.76E-01	5.53E-01	8.82E+05	3.20E+03
SD01-8	121	844	2.47E+06	8.97E-01	5.53E-01	8.85E+05	4.00E+03
SD01-8	122	844	1.39E+06	5.07E-01	5.61E-01	8.89E+05	3.20E+03
SD01-8	123	844	1.36E+06	4.95E-01	5.61E-01	8.92E+05	4.00E+03
SD01-8	124	844	1.32E+06	4.80E-01	5.61E-01	8.96E+05	4.00E+03
SD03	1	820	4.65E+03	1.67E-03	5.00E-01	9.58E+05	2.20E+04
SD03	2	821	3.85E+03	1.38E-03	5.00E-01	9.58E+05	2.20E+04
SD03	3	824	2.09E+03	7.50E-04	5.00E-01	9.58E+05	2.20E+04
SD03	4	842	5.71E+06	2.08E+00	5.29E-01	9.58E+05	4.00E+03
SD03	5	842	3.51E+06	1.27E+00	5.22E-01	9.62E+05	3.00E+03
SD03	6	842	3.27E+06	1.18E+00	5.16E-01	9.65E+05	4.00E+03
SD03	7	842	3.20E+06	1.16E+00	5.12E-01	9.69E+05	3.00E+03
SD03	8	842	3.17E+06	1.15E+00	5.11E-01	9.72E+05	4.00E+03
SD03	9	842	3.29E+06	1.19E+00	5.04E-01	9.76E+05	4.00E+03
SD03	10	820	4.55E+03	1.63E-03	4.90E-01	9.80E+05	2.10E+04
SD03	11	821	3.78E+03	1.35E-03	4.90E-01	9.80E+05	2.10E+04
SD03	12	824	2.05E+03	7.33E-04	4.91E-01	9.80E+05	2.10E+04
SD03	13	842	3.16E+06	1.14E+00	5.04E-01	9.80E+05	3.00E+03
SD03	14	842	3.13E+06	1.13E+00	5.04E-01	9.83E+05	4.00E+03
SD03	15	842	3.09E+06	1.12E+00	5.04E-01	9.87E+05	3.00E+03
SD03	16	842	3.19E+06	1.15E+00	5.03E-01	9.90E+05	4.00E+03
SD03	17	842	3.14E+06	1.13E+00	5.05E-01	9.94E+05	4.00E+03
SD03	18	842	3.10E+06	1.12E+00	5.05E-01	9.98E+05	3.00E+03
SD03	19	820	4.83E+03	1.73E-03	4.93E-01	1.00E+06	2.20E+04
SD03	20	821	4.00E+03	1.43E-03	4.93E-01	1.00E+06	2.20E+04
SD03	21	824	2.17E+03	7.78E-04	4.93E-01	1.00E+06	2.20E+04
SD03	22	842	4.27E+06	1.54E+00	4.99E-01	1.00E+06	4.00E+03
SD03	23	842	4.93E+06	1.76E+00	4.90E-01	1.00E+06	3.00E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD03	24	842	3.28E+06	1.17E+00	4.87E-01	1.01E+06	4.00E+03
SD03	25	842	3.21E+06	1.14E+00	4.84E-01	1.01E+06	4.00E+03
SD03	26	842	3.16E+06	1.12E+00	4.82E-01	1.02E+06	3.00E+03
SD03	27	842	3.12E+06	1.11E+00	4.77E-01	1.02E+06	4.00E+03
SD03	28	820	4.41E+03	1.57E-03	4.84E-01	1.02E+06	2.10E+04
SD03	29	821	3.65E+03	1.30E-03	4.84E-01	1.02E+06	2.10E+04
SD03	30	824	1.98E+03	7.06E-04	4.84E-01	1.02E+06	2.10E+04
SD03	31	842	3.10E+06	1.09E+00	4.75E-01	1.02E+06	3.00E+03
SD03	32	842	3.06E+06	1.08E+00	4.73E-01	1.03E+06	4.00E+03
SD03	33	842	3.02E+06	1.07E+00	4.71E-01	1.03E+06	4.00E+03
SD03	34	842	2.99E+06	1.05E+00	4.69E-01	1.03E+06	3.00E+03
SD03	35	842	2.96E+06	1.04E+00	4.68E-01	1.04E+06	4.00E+03
SD03	36	842	2.93E+06	1.03E+00	4.67E-01	1.04E+06	3.00E+03
SD03	37	820	4.11E+03	1.46E-03	4.76E-01	1.04E+06	2.20E+04
SD03	38	821	3.41E+03	1.21E-03	4.76E-01	1.04E+06	2.20E+04
SD03	39	824	1.85E+03	6.55E-04	4.76E-01	1.04E+06	2.20E+04
SD03	40	842	2.90E+06	1.02E+00	4.66E-01	1.04E+06	4.00E+03
SD03	41	842	2.87E+06	1.01E+00	4.64E-01	1.05E+06	4.00E+03
SD03	42	842	2.85E+06	9.97E-01	4.62E-01	1.05E+06	3.00E+03
SD03	43	842	2.83E+06	9.89E-01	4.61E-01	1.05E+06	4.00E+03
SD03	44	842	2.81E+06	9.80E-01	4.59E-01	1.06E+06	3.00E+03
SD03	45	842	2.79E+06	9.73E-01	4.56E-01	1.06E+06	4.00E+03
SD03	46	820	3.92E+03	1.38E-03	4.69E-01	1.07E+06	2.20E+04
SD03	47	821	3.25E+03	1.14E-03	4.69E-01	1.07E+06	2.20E+04
SD03	48	824	1.76E+03	6.19E-04	4.69E-01	1.07E+06	2.20E+04
SD03	49	842	2.78E+06	9.67E-01	4.55E-01	1.07E+06	4.00E+03
SD03	50	842	2.76E+06	9.61E-01	4.55E-01	1.07E+06	3.00E+03
SD03	51	842	2.74E+06	9.55E-01	4.56E-01	1.07E+06	4.00E+03
SD03	52	842	2.72E+06	9.48E-01	4.56E-01	1.08E+06	3.00E+03
SD03	53	842	2.70E+06	9.41E-01	4.55E-01	1.08E+06	4.00E+03
SD03	54	842	2.68E+06	9.34E-01	4.54E-01	1.08E+06	4.00E+03
SD03	55	820	3.74E+03	1.31E-03	4.66E-01	1.09E+06	2.10E+04
SD03	56	821	3.10E+03	1.09E-03	4.66E-01	1.09E+06	2.10E+04
SD03	57	824	1.68E+03	5.90E-04	4.66E-01	1.09E+06	2.10E+04
SD03	58	842	2.67E+06	9.28E-01	4.54E-01	1.09E+06	3.00E+03
SD03	59	842	2.65E+06	9.22E-01	4.53E-01	1.09E+06	4.00E+03
SD03	60	842	2.64E+06	9.16E-01	4.52E-01	1.09E+06	3.00E+03
SD03	61	842	2.62E+06	9.11E-01	4.51E-01	1.10E+06	4.00E+03
SD03	62	842	2.61E+06	9.05E-01	4.51E-01	1.10E+06	4.00E+03
SD03	63	842	2.60E+06	9.01E-01	4.50E-01	1.11E+06	3.00E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD03	64	842	2.59E+06	8.96E-01	4.49E-01	1.11E+06	3.80E+03
SD05	1	9609	1.07E+08	2.57E+01	1.00E+00	8.66E+05	3.98E+03
SD05	2	9599	1.65E+06	3.93E-01	9.64E-01	8.69E+05	2.80E+03
SD05	3	9609	1.15E+08	2.73E+01	9.76E-01	8.70E+05	3.73E+03
SD05	4	9599	2.74E+05	6.46E-02	9.82E-01	8.72E+05	4.00E+03
SD05	5	9609	1.13E+08	2.67E+01	9.74E-01	8.73E+05	3.31E+03
SD05	6	9599	1.27E+06	3.00E-01	9.44E-01	8.76E+05	4.00E+03
SD05	7	9609	1.13E+08	2.68E+01	9.81E-01	8.77E+05	2.99E+03
SD05	8	9599	4.57E+04	1.09E-02	9.50E-01	8.80E+05	4.00E+03
SD05	9	9609	1.22E+08	2.91E+01	9.45E-01	8.80E+05	4.00E+03
SD05	10	9609	1.16E+08	2.75E+01	9.64E-01	8.84E+05	3.27E+03
SD05	11	9609	1.15E+08	2.71E+01	9.80E-01	8.87E+05	3.89E+03
SD05	12	9609	1.06E+08	2.50E+01	9.99E-01	8.91E+05	2.84E+03
SD05	13	9599	2.67E+06	6.30E-01	9.43E-01	8.94E+05	4.00E+03
SD05	14	9609	1.15E+08	2.75E+01	9.78E-01	8.94E+05	4.00E+03
SD05	15	9609	1.02E+08	2.42E+01	1.01E+00	8.98E+05	4.00E+03
SD05	16	9609	1.02E+08	2.41E+01	1.02E+00	9.02E+05	3.46E+03
SD05	17	9609	1.05E+08	2.46E+01	1.01E+00	9.05E+05	4.54E+03
SD05	18	9609	1.05E+08	2.46E+01	1.01E+00	9.10E+05	2.00E+03
SD05	19	9609	1.05E+08	2.46E+01	1.01E+00	9.12E+05	4.00E+03
SD05	20	9609	1.06E+08	2.47E+01	1.01E+00	9.16E+05	4.00E+03
SD05	21	9609	1.06E+08	2.49E+01	1.01E+00	9.20E+05	4.00E+03
SD05	22	9609	1.07E+08	2.50E+01	1.01E+00	9.24E+05	4.00E+03
SD05	23	9609	1.07E+08	2.51E+01	1.01E+00	9.28E+05	2.00E+03
SD05	24	9609	1.08E+08	2.52E+01	1.01E+00	9.30E+05	4.00E+03
SD05	25	9609	1.08E+08	2.53E+01	1.00E+00	9.34E+05	4.00E+03
SD05	26	9609	1.08E+08	2.53E+01	1.00E+00	9.38E+05	4.00E+03
SD05	27	9609	1.09E+08	2.54E+01	1.00E+00	9.42E+05	4.00E+03
SD05	28	9609	1.09E+08	2.56E+01	1.00E+00	9.46E+05	2.00E+03
SD05	29	9609	1.10E+08	2.57E+01	9.98E-01	9.48E+05	4.00E+03
SD05	30	9609	1.10E+08	2.58E+01	9.96E-01	9.52E+05	4.00E+03
SD05	31	9609	1.11E+08	2.59E+01	9.94E-01	9.56E+05	4.00E+03
SD05	32	9609	1.11E+08	2.61E+01	9.92E-01	9.60E+05	4.00E+03
SD05	33	9609	1.12E+08	2.62E+01	9.90E-01	9.64E+05	2.00E+03
SD05	34	9609	1.12E+08	2.63E+01	9.89E-01	9.66E+05	4.00E+03
SD05	35	9609	1.13E+08	2.63E+01	9.88E-01	9.70E+05	4.00E+03
SD05	36	9609	1.13E+08	2.63E+01	9.87E-01	9.74E+05	4.00E+03
SD05	37	9609	1.13E+08	2.63E+01	9.87E-01	9.78E+05	4.00E+03
SD05	38	9609	1.13E+08	2.64E+01	9.87E-01	9.82E+05	2.00E+03
SD05	39	9609	1.13E+08	2.64E+01	9.86E-01	9.84E+05	4.00E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD05	40	9609	1.13E+08	2.65E+01	9.85E-01	9.88E+05	4.00E+03
SD05	41	9609	1.13E+08	2.65E+01	9.84E-01	9.92E+05	4.00E+03
SD05	42	9609	1.14E+08	2.66E+01	9.83E-01	9.96E+05	4.00E+03
SD05	43	9609	1.14E+08	2.66E+01	9.83E-01	1.00E+06	2.00E+03
SD05	44	9609	1.14E+08	2.67E+01	9.82E-01	1.00E+06	4.00E+03
SD05	45	9609	1.14E+08	2.67E+01	9.81E-01	1.01E+06	4.00E+03
SD05	46	9609	1.14E+08	2.68E+01	9.80E-01	1.01E+06	4.00E+03
SD05	47	9609	1.15E+08	2.68E+01	9.80E-01	1.01E+06	4.00E+03
SD05	48	9609	1.15E+08	2.68E+01	9.79E-01	1.02E+06	2.00E+03
SD05	49	9609	1.15E+08	2.69E+01	9.79E-01	1.02E+06	4.00E+03
SD05	50	9609	1.15E+08	2.69E+01	9.78E-01	1.02E+06	4.00E+03
SD05	51	9609	1.15E+08	2.69E+01	9.77E-01	1.03E+06	4.00E+03
SD05	52	9609	1.15E+08	2.70E+01	9.77E-01	1.03E+06	4.00E+03
SD05	53	9609	1.15E+08	2.70E+01	9.77E-01	1.04E+06	2.00E+03
SD05	54	9609	1.16E+08	2.70E+01	9.76E-01	1.04E+06	4.00E+03
SD05	55	9609	1.16E+08	2.70E+01	9.76E-01	1.04E+06	4.00E+03
SD05	56	9609	1.16E+08	2.71E+01	9.75E-01	1.05E+06	4.00E+03
SD05	57	9609	1.17E+08	2.73E+01	9.72E-01	1.05E+06	4.00E+03
SD05	58	9609	1.17E+08	2.74E+01	9.70E-01	1.05E+06	2.00E+03
SD05	59	9609	1.17E+08	2.74E+01	9.69E-01	1.06E+06	4.00E+03
SD05	60	9609	1.18E+08	2.75E+01	9.68E-01	1.06E+06	4.00E+03
SD05	61	9609	1.18E+08	2.75E+01	9.67E-01	1.06E+06	4.00E+03
SD05	62	9609	1.18E+08	2.76E+01	9.67E-01	1.07E+06	4.00E+03
SD05	63	9609	1.18E+08	2.76E+01	9.66E-01	1.07E+06	2.00E+03
SD05	64	9609	1.18E+08	2.76E+01	9.66E-01	1.07E+06	4.00E+03
SD05	65	9609	1.18E+08	2.76E+01	9.65E-01	1.08E+06	4.00E+03
SD05	66	9609	1.19E+08	2.79E+01	9.63E-01	1.08E+06	4.00E+03
SD05	67	9609	1.19E+08	2.80E+01	9.60E-01	1.09E+06	4.00E+03
SD05	68	9609	1.19E+08	2.78E+01	9.62E-01	1.09E+06	2.00E+03
SD05	69	9609	1.19E+08	2.77E+01	9.64E-01	1.09E+06	4.00E+03
SD05	70	9609	1.19E+08	2.77E+01	9.64E-01	1.10E+06	4.00E+03
SD05	71	9609	1.19E+08	2.78E+01	9.63E-01	1.10E+06	4.00E+03
SD05	72	9609	1.19E+08	2.78E+01	9.63E-01	1.10E+06	4.00E+03
SD05	73	9609	1.19E+08	2.78E+01	9.63E-01	1.11E+06	2.00E+03
SD05	74	9609	1.19E+08	2.78E+01	9.63E-01	1.11E+06	2.80E+03
SD07	1	9599	1.61E+07	3.92E+00	9.78E-01	9.92E+04	3.60E+03
SD07	2	9609	1.09E+08	2.64E+01	9.74E-01	9.92E+04	3.60E+03
SD07	3	9599	2.00E+07	4.84E+00	9.65E-01	1.03E+05	3.60E+03
SD07	4	9609	1.10E+08	2.66E+01	9.64E-01	1.03E+05	3.60E+03
SD07	5	9599	4.10E+06	9.85E-01	9.89E-01	1.06E+05	3.60E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD07	6	9609	1.06E+08	2.54E+01	9.80E-01	1.06E+05	3.60E+03
SD07	7	9599	9.77E+06	2.33E+00	9.59E-01	1.10E+05	3.60E+03
SD07	8	9609	1.09E+08	2.60E+01	9.83E-01	1.10E+05	3.60E+03
SD07	9	9599	3.17E+06	7.69E-01	9.34E-01	1.14E+05	3.60E+03
SD07	10	9609	1.05E+08	2.54E+01	9.63E-01	1.14E+05	3.60E+03
SD07	11	9599	7.74E+06	1.85E+00	8.75E-01	1.17E+05	3.60E+03
SD07	12	9609	1.24E+08	3.02E+01	9.35E-01	1.17E+05	3.60E+03
SD07	13	9599	9.31E+05	2.23E-01	9.56E-01	1.21E+05	3.60E+03
SD07	14	9609	1.16E+08	2.77E+01	9.61E-01	1.21E+05	3.60E+03
SD07	15	9609	1.17E+08	2.76E+01	9.70E-01	1.24E+05	3.60E+03
SD07	16	9609	1.17E+08	2.76E+01	9.69E-01	1.28E+05	3.60E+03
SD07	17	9609	1.18E+08	2.77E+01	9.68E-01	1.32E+05	3.60E+03
SD07	18	9609	1.18E+08	2.78E+01	9.66E-01	1.35E+05	3.60E+03
SD07	19	9609	1.19E+08	2.80E+01	9.63E-01	1.39E+05	3.60E+03
SD07	20	9609	1.20E+08	2.81E+01	9.61E-01	1.42E+05	3.60E+03
SD07	21	9609	1.20E+08	2.82E+01	9.59E-01	1.46E+05	3.60E+03
SD07	22	9609	1.21E+08	2.83E+01	9.57E-01	1.50E+05	3.60E+03
SD07	23	9609	1.21E+08	2.84E+01	9.55E-01	1.53E+05	3.60E+03
SD07	24	9609	1.21E+08	2.85E+01	9.54E-01	1.57E+05	3.60E+03
SD07	25	9609	1.21E+08	2.85E+01	9.53E-01	1.60E+05	3.60E+03
SD07	26	9609	1.22E+08	2.86E+01	9.52E-01	1.64E+05	3.60E+03
SD07	27	9609	1.22E+08	2.86E+01	9.51E-01	1.68E+05	3.60E+03
SD07	28	9609	1.22E+08	2.86E+01	9.50E-01	1.71E+05	3.60E+03
SD07	29	9609	1.22E+08	2.87E+01	9.50E-01	1.75E+05	3.60E+03
SD07	30	9609	1.22E+08	2.87E+01	9.49E-01	1.78E+05	3.60E+03
SD07	31	9609	1.23E+08	2.87E+01	9.49E-01	1.82E+05	3.60E+03
SD07	32	9609	1.23E+08	2.88E+01	9.48E-01	1.86E+05	3.60E+03
SD07	33	9609	1.23E+08	2.88E+01	9.47E-01	1.89E+05	3.60E+03
SD07	34	9609	1.23E+08	2.88E+01	9.47E-01	1.93E+05	3.60E+03
SD07	35	9609	1.23E+08	2.89E+01	9.46E-01	1.96E+05	3.60E+03
SD07	36	9609	1.23E+08	2.89E+01	9.46E-01	2.00E+05	3.60E+03
SD07	37	9609	1.23E+08	2.89E+01	9.45E-01	2.04E+05	3.60E+03
SD07	38	9609	1.23E+08	2.89E+01	9.45E-01	2.07E+05	3.60E+03
SD07	39	9609	1.24E+08	2.89E+01	9.44E-01	2.11E+05	3.60E+03
SD07	40	9609	1.24E+08	2.90E+01	9.44E-01	2.14E+05	3.60E+03
SD07	41	9609	1.24E+08	2.90E+01	9.43E-01	2.18E+05	3.60E+03
SD07	42	9609	1.24E+08	2.90E+01	9.43E-01	2.22E+05	3.60E+03
SD07	43	9609	1.24E+08	2.91E+01	9.42E-01	2.25E+05	3.60E+03
SD07	44	9609	1.24E+08	2.91E+01	9.42E-01	2.29E+05	3.60E+03
SD07	45	9609	1.24E+08	2.91E+01	9.41E-01	2.32E+05	3.60E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD07	46	9609	1.24E+08	2.91E+01	9.41E-01	2.36E+05	3.60E+03
SD07	47	9609	1.25E+08	2.92E+01	9.40E-01	2.40E+05	3.60E+03
SD07	48	9609	1.25E+08	2.92E+01	9.40E-01	2.43E+05	4.00E+03
SD07	49	9609	1.25E+08	2.92E+01	9.39E-01	2.47E+05	4.00E+03
SD07	50	9609	1.25E+08	2.92E+01	9.39E-01	2.51E+05	2.00E+03
SD07	51	9609	1.25E+08	2.93E+01	9.39E-01	2.53E+05	4.00E+03
SD07	52	9609	1.25E+08	2.93E+01	9.38E-01	2.57E+05	4.00E+03
SD07	53	9609	1.25E+08	2.93E+01	9.38E-01	2.61E+05	4.00E+03
SD07	54	9609	1.25E+08	2.93E+01	9.37E-01	2.65E+05	4.00E+03
SD07	55	9609	1.25E+08	2.93E+01	9.37E-01	2.69E+05	2.00E+03
SD07	56	9609	1.25E+08	2.94E+01	9.37E-01	2.71E+05	4.00E+03
SD07	57	9609	1.25E+08	2.94E+01	9.36E-01	2.75E+05	4.00E+03
SD07	58	9609	1.26E+08	2.94E+01	9.36E-01	2.79E+05	4.00E+03
SD07	59	9609	1.26E+08	2.94E+01	9.36E-01	2.83E+05	4.00E+03
SD07	60	9609	1.25E+08	2.93E+01	9.36E-01	2.87E+05	2.00E+03
SD07	61	9609	1.25E+08	2.93E+01	9.37E-01	2.89E+05	4.00E+03
SD07	62	9609	1.25E+08	2.93E+01	9.37E-01	2.93E+05	4.00E+03
SD07	63	9609	1.25E+08	2.93E+01	9.36E-01	2.97E+05	4.00E+03
SD07	64	9609	1.26E+08	2.93E+01	9.36E-01	3.01E+05	4.00E+03
SD07	65	9609	1.26E+08	2.94E+01	9.36E-01	3.05E+05	2.00E+03
SD07	66	9609	1.26E+08	2.94E+01	9.35E-01	3.07E+05	4.00E+03
SD07	67	9609	1.26E+08	2.94E+01	9.35E-01	3.11E+05	4.00E+03
SD07	68	9609	1.26E+08	2.94E+01	9.35E-01	3.15E+05	4.00E+03
SD07	69	9609	1.26E+08	2.94E+01	9.35E-01	3.19E+05	4.00E+03
SD07	70	9609	1.26E+08	2.95E+01	9.34E-01	3.23E+05	2.00E+03
SD07	71	9609	1.26E+08	2.95E+01	9.32E-01	3.25E+05	4.00E+03
SD07	72	9609	1.26E+08	2.95E+01	9.33E-01	3.29E+05	4.00E+03
SD07	73	9609	1.26E+08	2.95E+01	9.33E-01	3.33E+05	4.00E+03
SD07	74	9609	1.26E+08	2.95E+01	9.33E-01	3.37E+05	4.00E+03
SD07	75	9609	1.26E+08	2.96E+01	9.32E-01	3.41E+05	2.00E+03
SD07	76	9609	1.26E+08	2.96E+01	9.32E-01	3.43E+05	4.00E+03
SD07	77	9609	1.27E+08	2.96E+01	9.32E-01	3.47E+05	4.00E+03
SD07	78	9609	1.27E+08	2.96E+01	9.31E-01	3.51E+05	4.00E+03
SD07	79	9609	1.27E+08	2.96E+01	9.32E-01	3.55E+05	4.00E+03
SD07	80	9609	1.27E+08	2.96E+01	9.31E-01	3.59E+05	4.00E+03
SD07	81	9609	1.27E+08	2.97E+01	9.31E-01	3.63E+05	8.00E+03
SD07	82	9609	1.27E+08	2.97E+01	9.28E-01	3.71E+05	8.00E+03
SD07	83	9609	1.28E+08	3.00E+01	9.24E-01	3.79E+05	8.00E+03
SD07	84	9609	1.29E+08	3.01E+01	9.22E-01	3.87E+05	8.00E+03
SD07	85	9609	1.29E+08	3.02E+01	9.21E-01	3.95E+05	8.00E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD07	86	9609	1.29E+08	3.02E+01	9.20E-01	4.03E+05	8.00E+03
SD07	87	9609	1.29E+08	3.02E+01	9.20E-01	4.11E+05	8.00E+03
SD07	88	9609	1.30E+08	3.02E+01	9.19E-01	4.19E+05	8.00E+03
SD07	89	9609	1.30E+08	3.03E+01	9.18E-01	4.27E+05	8.00E+03
SD07	90	9609	1.30E+08	3.03E+01	9.18E-01	4.35E+05	6.44E+02
SD07	91	9609	1.30E+08	3.03E+01	9.18E-01	4.36E+05	7.36E+03
SD07	92	9609	1.30E+08	3.03E+01	9.18E-01	4.43E+05	8.00E+03
SD07	93	9609	1.30E+08	3.03E+01	9.18E-01	4.51E+05	8.00E+03
SD07	94	9609	1.30E+08	3.03E+01	9.18E-01	4.59E+05	8.00E+03
SD07	95	9609	1.30E+08	3.03E+01	9.17E-01	4.67E+05	2.00E+03
SD07	96	9609	1.30E+08	3.04E+01	9.16E-01	4.69E+05	5.00E+03
SD07	97	9609	1.30E+08	3.03E+01	9.16E-01	4.74E+05	5.00E+03
SD07	98	9609	1.30E+08	3.04E+01	9.16E-01	4.79E+05	4.00E+03
SD07	99	9609	1.30E+08	3.04E+01	9.16E-01	4.83E+05	4.00E+03
SD07	100	9609	1.30E+08	3.04E+01	9.15E-01	4.87E+05	4.00E+03
SD07	101	9609	1.30E+08	3.04E+01	9.15E-01	4.91E+05	4.00E+03
SD07	102	9609	1.31E+08	3.05E+01	9.14E-01	4.95E+05	4.00E+03
SD07	103	9609	1.31E+08	3.05E+01	9.14E-01	4.99E+05	4.00E+03
SD07	104	9609	1.30E+08	3.04E+01	9.15E-01	5.03E+05	4.00E+03
SD07	105	9609	1.30E+08	3.03E+01	9.16E-01	5.07E+05	4.00E+03
SD07	106	9609	1.30E+08	3.01E+01	9.17E-01	5.11E+05	4.00E+03
SD07	107	9609	1.30E+08	3.02E+01	9.17E-01	5.15E+05	4.00E+03
SD07	108	9609	1.30E+08	3.02E+01	9.16E-01	5.19E+05	4.00E+03
SD07	109	9609	1.30E+08	3.02E+01	9.16E-01	5.23E+05	4.00E+03
SD07	110	9609	1.30E+08	3.03E+01	9.15E-01	5.27E+05	4.00E+03
SD07	111	9609	1.30E+08	3.03E+01	9.15E-01	5.31E+05	4.00E+03
SD07	112	9609	1.31E+08	3.03E+01	9.13E-01	5.35E+05	4.00E+03
SD07	113	9609	1.31E+08	3.04E+01	9.13E-01	5.39E+05	4.00E+03
SD07	114	9609	1.31E+08	3.04E+01	9.12E-01	5.43E+05	4.00E+03
SD07	115	9609	1.31E+08	3.04E+01	9.12E-01	5.47E+05	4.00E+03
SD07	116	9609	1.31E+08	3.05E+01	9.11E-01	5.51E+05	4.00E+03
SD07	117	9609	1.31E+08	3.04E+01	9.11E-01	5.55E+05	4.00E+03
SD07	118	9609	1.31E+08	3.05E+01	9.11E-01	5.59E+05	4.00E+03
SD07	119	9609	1.32E+08	3.05E+01	9.10E-01	5.63E+05	4.00E+03
SD07	120	9609	1.32E+08	3.05E+01	9.09E-01	5.67E+05	4.00E+03
SD07	121	9609	1.31E+08	3.05E+01	9.10E-01	5.71E+05	4.00E+03
SD07	122	9609	1.32E+08	3.05E+01	9.10E-01	5.75E+05	4.00E+03
SD07	123	9609	1.32E+08	3.05E+01	9.10E-01	5.79E+05	4.00E+03
SD07	124	9609	1.32E+08	3.06E+01	9.10E-01	5.83E+05	4.00E+03
SD07	125	9609	1.31E+08	3.05E+01	9.10E-01	5.87E+05	4.00E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD07	126	9609	1.32E+08	3.05E+01	9.09E-01	5.91E+05	4.00E+03
SD07	127	9609	1.32E+08	3.06E+01	9.08E-01	5.95E+05	4.00E+03
SD07	128	9609	1.32E+08	3.06E+01	9.08E-01	5.99E+05	4.00E+03
SD07	129	9609	1.32E+08	3.06E+01	9.07E-01	6.03E+05	3.60E+03
SD07	130	9609	1.32E+08	3.07E+01	9.06E-01	6.07E+05	2.40E+03
SD07	131	9609	1.32E+08	3.06E+01	9.06E-01	6.09E+05	4.00E+03
SD07	132	9609	1.32E+08	3.06E+01	9.06E-01	6.13E+05	4.00E+03
SD07	133	9609	1.32E+08	3.06E+01	9.06E-01	6.17E+05	4.00E+03
SD07	134	9609	1.32E+08	3.06E+01	9.07E-01	6.21E+05	4.00E+03
SD07	135	9609	1.32E+08	3.07E+01	9.07E-01	6.25E+05	4.00E+03
SD07	136	9609	1.32E+08	3.07E+01	9.06E-01	6.29E+05	4.00E+03
SD07	137	9609	1.32E+08	3.07E+01	9.05E-01	6.33E+05	4.00E+03
SD07	138	9609	1.32E+08	3.07E+01	9.06E-01	6.37E+05	4.00E+03
SD07	139	9609	1.32E+08	3.07E+01	9.05E-01	6.41E+05	6.80E+03
SD08-2	1	820	1.54E+03	4.02E-04	9.60E-01	1.20E+05	2.16E+04
SD08-2	2	821	1.28E+03	3.36E-04	9.70E-01	1.20E+05	2.16E+04
SD08-2	3	824	6.94E+02	1.81E-04	9.71E-01	1.20E+05	2.16E+04
SD08-2	4	820	1.43E+03	4.28E-04	9.10E-01	1.41E+05	2.19E+04
SD08-2	5	821	1.20E+03	3.63E-04	9.42E-01	1.41E+05	2.19E+04
SD08-2	6	824	6.50E+02	1.96E-04	9.44E-01	1.41E+05	2.19E+04
SD08-2	7	820	1.15E+03	3.98E-04	9.14E-01	1.63E+05	2.16E+04
SD08-2	8	821	9.64E+02	3.36E-04	9.41E-01	1.63E+05	2.16E+04
SD08-2	9	824	5.21E+02	1.82E-04	9.43E-01	1.63E+05	2.16E+04
SD08-2	10	820	8.46E+02	3.63E-04	8.76E-01	1.85E+05	2.16E+04
SD08-2	11	821	7.21E+02	3.14E-04	9.40E-01	1.85E+05	2.16E+04
SD08-2	12	824	3.89E+02	1.70E-04	9.43E-01	1.85E+05	2.16E+04
SD08-2	13	820	5.90E+02	3.21E-04	9.08E-01	2.07E+05	2.11E+04
SD08-2	14	821	4.93E+02	2.73E-04	9.45E-01	2.07E+05	2.11E+04
SD08-2	15	824	2.69E+02	1.49E-04	9.47E-01	2.07E+05	2.11E+04
SD08-2	16	820	4.72E+02	3.06E-04	9.35E-01	2.28E+05	2.16E+04
SD08-2	17	821	3.90E+02	2.53E-04	9.35E-01	2.28E+05	2.16E+04
SD08-2	18	824	2.16E+02	1.40E-04	9.37E-01	2.28E+05	2.16E+04
SD08-2	19	820	5.37E+02	3.45E-04	9.04E-01	2.49E+05	2.16E+04
SD08-2	20	821	4.44E+02	2.85E-04	9.04E-01	2.49E+05	2.16E+04
SD08-2	21	824	2.40E+02	1.54E-04	9.06E-01	2.49E+05	2.16E+04
SD08-2	22	820	6.07E+02	3.84E-04	8.74E-01	2.71E+05	2.16E+04
SD08-2	23	821	5.02E+02	3.18E-04	8.74E-01	2.71E+05	2.16E+04
SD08-2	24	824	2.71E+02	1.72E-04	8.75E-01	2.71E+05	2.16E+04
SD08-2	25	820	6.75E+02	4.21E-04	8.46E-01	2.92E+05	2.16E+04
SD08-2	26	821	5.59E+02	3.48E-04	8.46E-01	2.92E+05	2.16E+04

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD08-2	27	824	3.02E+02	1.88E-04	8.47E-01	2.92E+05	2.16E+04
SD08-2	28	820	7.40E+02	4.55E-04	8.21E-01	3.14E+05	2.16E+04
SD08-2	29	821	6.12E+02	3.77E-04	8.21E-01	3.14E+05	2.16E+04
SD08-2	30	824	3.31E+02	2.03E-04	8.22E-01	3.14E+05	2.16E+04
SD08-2	31	820	8.00E+02	4.86E-04	7.99E-01	3.36E+05	2.16E+04
SD08-2	32	821	6.63E+02	4.02E-04	7.99E-01	3.36E+05	2.16E+04
SD08-2	33	824	3.58E+02	2.17E-04	7.99E-01	3.36E+05	2.16E+04
SD08-2	34	820	8.52E+02	5.11E-04	7.81E-01	3.57E+05	2.16E+04
SD08-2	35	821	7.05E+02	4.23E-04	7.81E-01	3.57E+05	2.16E+04
SD08-2	36	824	3.81E+02	2.29E-04	7.81E-01	3.57E+05	2.16E+04
SD08-2	37	820	8.96E+02	5.31E-04	7.67E-01	3.79E+05	2.16E+04
SD08-2	38	821	7.42E+02	4.40E-04	7.67E-01	3.79E+05	2.16E+04
SD08-2	39	824	4.01E+02	2.38E-04	7.68E-01	3.79E+05	2.16E+04
SD08-2	40	820	9.32E+02	5.46E-04	7.62E-01	4.00E+05	2.16E+04
SD08-2	41	821	7.72E+02	4.52E-04	7.62E-01	4.00E+05	2.16E+04
SD08-2	42	824	4.17E+02	2.45E-04	7.62E-01	4.00E+05	2.16E+04
SD08-2	43	820	9.62E+02	5.58E-04	7.57E-01	4.22E+05	2.16E+04
SD08-2	44	821	7.97E+02	4.62E-04	7.57E-01	4.22E+05	2.16E+04
SD08-2	45	824	4.31E+02	2.50E-04	7.58E-01	4.22E+05	2.16E+04
SD08-2	46	820	9.89E+02	5.69E-04	7.54E-01	4.44E+05	2.16E+04
SD08-2	47	821	8.20E+02	4.71E-04	7.54E-01	4.44E+05	2.16E+04
SD08-2	48	824	4.43E+02	2.55E-04	7.54E-01	4.44E+05	2.16E+04
SD08-2	49	820	1.02E+03	5.79E-04	7.50E-01	4.65E+05	2.16E+04
SD08-2	50	821	8.42E+02	4.80E-04	7.50E-01	4.65E+05	2.16E+04
SD08-2	51	824	4.55E+02	2.59E-04	7.50E-01	4.65E+05	2.16E+04
SD08-2	52	820	1.04E+03	5.87E-04	7.48E-01	4.87E+05	2.16E+04
SD08-2	53	821	8.60E+02	4.86E-04	7.48E-01	4.87E+05	2.16E+04
SD08-2	54	824	4.65E+02	2.63E-04	7.48E-01	4.87E+05	2.16E+04
SD08-2	55	820	1.07E+03	5.99E-04	7.42E-01	5.08E+05	2.16E+04
SD08-2	56	821	8.86E+02	4.96E-04	7.42E-01	5.08E+05	2.16E+04
SD08-2	57	824	4.79E+02	2.68E-04	7.43E-01	5.08E+05	2.16E+04
SD08-2	58	820	1.09E+03	6.05E-04	7.41E-01	5.30E+05	2.16E+04
SD08-2	59	821	9.02E+02	5.01E-04	7.41E-01	5.30E+05	2.16E+04
SD08-2	60	824	4.88E+02	2.71E-04	7.41E-01	5.30E+05	2.16E+04
SD08-2	61	820	1.11E+03	6.12E-04	7.40E-01	5.52E+05	2.16E+04
SD08-2	62	821	9.19E+02	5.07E-04	7.40E-01	5.52E+05	2.16E+04
SD08-2	63	824	4.97E+02	2.74E-04	7.40E-01	5.52E+05	2.16E+04
SD08-2	64	820	1.13E+03	6.18E-04	7.39E-01	5.73E+05	2.16E+04
SD08-2	65	821	9.35E+02	5.12E-04	7.39E-01	5.73E+05	2.16E+04
SD08-2	66	824	5.06E+02	2.77E-04	7.39E-01	5.73E+05	2.16E+04

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD08-2	67	820	1.15E+03	6.24E-04	7.38E-01	5.95E+05	2.16E+04
SD08-2	68	821	9.52E+02	5.17E-04	7.38E-01	5.95E+05	2.16E+04
SD08-2	69	824	5.15E+02	2.80E-04	7.38E-01	5.95E+05	2.16E+04
SD08-2	70	820	1.16E+03	6.28E-04	7.38E-01	6.16E+05	6.40E+03
SD08-2	71	821	9.61E+02	5.20E-04	7.38E-01	6.16E+05	6.40E+03
SD08-2	72	824	5.20E+02	2.81E-04	7.38E-01	6.16E+05	6.40E+03
SD09	1	820	9.66E+03	3.14E-03	5.10E-01	9.56E+05	2.16E+04
SD09	2	821	8.01E+03	2.61E-03	5.10E-01	9.56E+05	2.16E+04
SD09	3	824	4.35E+03	1.42E-03	5.10E-01	9.56E+05	2.16E+04
SD09	4	844	1.92E+07	6.34E+00	5.81E-01	9.56E+05	4.00E+03
SD09	5	844	1.88E+07	6.25E+00	5.78E-01	9.60E+05	3.00E+03
SD09	6	844	1.85E+07	6.17E+00	5.73E-01	9.63E+05	4.00E+03
SD09	7	844	1.82E+07	6.02E+00	5.78E-01	9.67E+05	3.58E+03
SD09	8	844	1.82E+07	5.99E+00	5.78E-01	9.70E+05	3.42E+03
SD09	9	844	1.75E+07	5.71E+00	5.83E-01	9.74E+05	3.56E+03
SD09	10	820	6.82E+03	2.26E-03	5.06E-01	9.77E+05	2.16E+04
SD09	11	821	5.65E+03	1.87E-03	5.06E-01	9.77E+05	2.16E+04
SD09	12	824	3.07E+03	1.02E-03	5.06E-01	9.77E+05	2.16E+04
SD09	13	844	1.67E+07	5.44E+00	5.88E-01	9.77E+05	3.56E+03
SD09	14	844	1.63E+07	5.33E+00	5.88E-01	9.81E+05	3.60E+03
SD09	15	844	1.58E+07	5.16E+00	5.92E-01	9.84E+05	3.40E+03
SD09	16	844	1.51E+07	4.90E+00	5.98E-01	9.88E+05	4.00E+03
SD09	17	844	1.50E+07	4.90E+00	5.94E-01	9.92E+05	3.00E+03
SD09	18	844	1.51E+07	4.93E+00	5.89E-01	9.95E+05	4.00E+03
SD09	19	820	5.07E+03	1.70E-03	5.02E-01	9.99E+05	2.20E+04
SD09	20	821	4.20E+03	1.41E-03	5.02E-01	9.99E+05	2.20E+04
SD09	21	844	1.44E+07	4.65E+00	5.89E-01	9.99E+05	4.00E+03
SD09	22	844	1.39E+07	4.48E+00	5.92E-01	1.00E+06	3.00E+03
SD09	23	844	1.34E+07	4.31E+00	5.94E-01	1.01E+06	4.00E+03
SD09	24	844	1.30E+07	4.15E+00	5.95E-01	1.01E+06	3.00E+03
SD09	25	844	1.26E+07	4.01E+00	5.97E-01	1.01E+06	4.00E+03
SD09	26	844	1.22E+07	3.86E+00	5.99E-01	1.02E+06	4.00E+03
SD09	27	844	1.18E+07	3.73E+00	6.01E-01	1.02E+06	3.00E+03
SD09	28	844	1.15E+07	3.62E+00	6.03E-01	1.02E+06	4.00E+03
SD09	29	844	1.12E+07	3.51E+00	6.05E-01	1.03E+06	3.00E+03
SD09	30	844	1.09E+07	3.41E+00	6.08E-01	1.03E+06	4.00E+03
SD09	31	844	1.06E+07	3.31E+00	6.10E-01	1.03E+06	4.00E+03
SD09	32	844	1.05E+07	3.29E+00	6.13E-01	1.04E+06	3.00E+03
SD09	33	844	1.05E+07	3.29E+00	6.13E-01	1.04E+06	4.00E+03
SD09	34	844	1.05E+07	3.29E+00	6.13E-01	1.05E+06	3.00E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD09	35	844	1.04E+07	3.28E+00	6.11E-01	1.05E+06	4.00E+03
SD09	36	844	1.04E+07	3.28E+00	6.11E-01	1.05E+06	4.00E+03
SD09	37	844	1.04E+07	3.28E+00	6.13E-01	1.06E+06	3.00E+03
SD09	38	844	1.03E+07	3.26E+00	6.13E-01	1.06E+06	4.00E+03
SD09	39	844	1.03E+07	3.25E+00	6.15E-01	1.06E+06	3.00E+03
SD09	40	844	1.03E+07	3.26E+00	6.15E-01	1.07E+06	4.00E+03
SD09	41	844	9.95E+06	3.14E+00	6.20E-01	1.07E+06	4.00E+03
SD09	42	844	9.58E+06	3.01E+00	6.25E-01	1.07E+06	3.00E+03
SD09	43	844	9.07E+06	2.85E+00	6.38E-01	1.08E+06	4.00E+03
SD09	44	844	5.43E+06	1.54E+00	7.34E-01	1.08E+06	3.00E+03
SD09	45	844	6.39E+06	1.83E+00	7.29E-01	1.08E+06	4.00E+03
SD09	46	844	1.01E+07	3.06E+00	6.38E-01	1.09E+06	4.00E+03
SD09	47	844	1.03E+07	3.19E+00	6.10E-01	1.09E+06	3.00E+03
SD09	48	844	6.50E+06	2.13E+00	6.01E-01	1.10E+06	4.00E+03
SD09	49	844	6.97E+06	2.20E+00	6.27E-01	1.10E+06	3.00E+03
SD09	50	844	7.63E+06	2.38E+00	6.38E-01	1.10E+06	4.00E+03
SD09	51	844	7.95E+06	2.47E+00	6.40E-01	1.11E+06	4.00E+03
SD09	52	844	8.08E+06	2.52E+00	6.41E-01	1.11E+06	1.68E+03
SD11-1	1	27	6.51E+06	1.57E+00	1.06E+00	1.23E+05	3.60E+03
SD11-1	2	27	7.01E+06	1.70E+00	1.01E+00	1.26E+05	3.60E+03
SD11-1	3	27	9.88E+06	2.35E+00	9.58E-01	1.30E+05	3.00E+02
SD11-1	4	995	3.06E+07	7.46E+00	8.16E-01	1.30E+05	3.40E+03
SD11-1	5	997	4.07E+07	9.70E+00	1.06E+00	1.30E+05	1.03E+02
SD11-1	6	998	1.22E+06	2.90E-01	1.04E+00	1.30E+05	3.40E+03
SD11-1	7	995	1.77E+07	4.39E+00	1.00E+00	1.33E+05	4.00E+03
SD11-1	8	995	1.79E+07	4.40E+00	1.00E+00	1.37E+05	4.00E+03
SD11-1	9	995	1.65E+07	4.04E+00	1.01E+00	1.41E+05	3.88E+03
SD11-1	10	995	1.69E+07	4.15E+00	1.02E+00	1.45E+05	3.28E+03
SD11-1	11	995	1.52E+07	3.70E+00	1.03E+00	1.49E+05	3.10E+03
SD11-1	12	820	2.15E+03	5.29E-04	8.98E-01	1.52E+05	2.17E+04
SD11-1	13	821	1.78E+03	4.39E-04	8.98E-01	1.52E+05	2.17E+04
SD11-1	14	824	9.64E+02	2.37E-04	8.99E-01	1.52E+05	2.17E+04
SD11-1	15	995	1.29E+07	3.14E+00	1.05E+00	1.52E+05	3.75E+03
SD11-1	16	995	1.28E+07	3.11E+00	1.06E+00	1.55E+05	4.00E+03
SD11-1	17	995	1.26E+07	3.05E+00	1.07E+00	1.59E+05	2.00E+03
SD11-1	18	995	1.24E+07	3.00E+00	1.07E+00	1.61E+05	4.00E+03
SD11-1	19	995	1.22E+07	2.95E+00	1.07E+00	1.65E+05	4.00E+03
SD11-1	20	995	1.20E+07	2.90E+00	1.08E+00	1.69E+05	4.00E+03
SD11-1	21	820	2.55E+03	6.61E-04	7.86E-01	1.73E+05	2.16E+04
SD11-1	22	821	2.13E+03	5.53E-04	7.93E-01	1.73E+05	2.16E+04

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD11-1	23	824	1.15E+03	3.00E-04	7.93E-01	1.73E+05	2.16E+04
SD11-1	24	995	1.19E+07	2.86E+00	1.08E+00	1.73E+05	4.00E+03
SD11-1	25	995	1.18E+07	2.84E+00	1.08E+00	1.77E+05	2.00E+03
SD11-1	26	995	1.17E+07	2.82E+00	1.08E+00	1.79E+05	4.00E+03
SD11-1	27	995	1.17E+07	2.81E+00	1.08E+00	1.83E+05	4.00E+03
SD11-1	28	995	1.16E+07	2.78E+00	1.08E+00	1.87E+05	4.00E+03
SD11-1	29	995	1.15E+07	2.76E+00	1.09E+00	1.91E+05	3.63E+03
SD11-1	30	820	2.56E+03	7.31E-04	7.44E-01	1.95E+05	2.20E+04
SD11-1	31	821	2.13E+03	6.10E-04	7.51E-01	1.95E+05	2.20E+04
SD11-1	32	824	1.15E+03	3.31E-04	7.51E-01	1.95E+05	2.20E+04
SD11-1	33	995	1.15E+07	2.75E+00	1.09E+00	1.95E+05	4.00E+03
SD11-1	34	995	1.14E+07	2.74E+00	1.09E+00	1.99E+05	2.00E+03
SD11-1	35	995	1.14E+07	2.74E+00	1.09E+00	2.01E+05	4.00E+03
SD11-1	36	995	1.14E+07	2.73E+00	1.09E+00	2.05E+05	4.00E+03
SD11-1	37	995	1.14E+07	2.73E+00	1.09E+00	2.09E+05	4.00E+03
SD11-1	38	995	1.14E+07	2.74E+00	1.09E+00	2.13E+05	4.00E+03
SD11-1	39	820	2.31E+03	7.70E-04	7.28E-01	2.17E+05	2.00E+04
SD11-1	40	821	1.91E+03	6.38E-04	7.28E-01	2.17E+05	2.00E+04
SD11-1	41	824	1.03E+03	3.46E-04	7.28E-01	2.17E+05	2.00E+04
SD11-1	42	995	1.13E+07	2.72E+00	1.09E+00	2.17E+05	2.00E+03
SD11-1	43	995	1.13E+07	2.72E+00	1.09E+00	2.19E+05	4.00E+03
SD11-1	44	995	1.13E+07	2.72E+00	1.09E+00	2.23E+05	4.00E+03
SD11-1	45	995	1.13E+07	2.72E+00	1.09E+00	2.27E+05	4.00E+03
SD11-1	46	995	1.13E+07	2.72E+00	1.09E+00	2.31E+05	4.00E+03
SD11-1	47	995	1.13E+07	2.73E+00	1.09E+00	2.35E+05	2.00E+03
SD11-1	48	820	2.36E+03	8.26E-04	6.71E-01	2.37E+05	2.22E+04
SD11-1	49	821	1.96E+03	6.92E-04	6.84E-01	2.37E+05	2.22E+04
SD11-1	50	824	1.06E+03	3.75E-04	6.84E-01	2.37E+05	2.22E+04
SD11-1	51	995	1.13E+07	2.73E+00	1.09E+00	2.37E+05	4.00E+03
SD11-1	52	995	1.14E+07	2.73E+00	1.09E+00	2.41E+05	2.17E+03
SD11-1	53	995	1.14E+07	2.74E+00	1.09E+00	2.43E+05	4.00E+03
SD11-1	54	995	1.14E+07	2.75E+00	1.09E+00	2.47E+05	4.00E+03
SD11-1	55	995	1.15E+07	2.78E+00	1.09E+00	2.51E+05	4.00E+03
SD11-1	56	995	1.15E+07	2.77E+00	1.09E+00	2.55E+05	4.00E+03
SD11-1	57	820	2.00E+03	8.68E-04	6.71E-01	2.59E+05	2.40E+04
SD11-1	58	821	1.66E+03	7.19E-04	6.71E-01	2.59E+05	2.40E+04
SD11-1	59	824	8.97E+02	3.90E-04	6.72E-01	2.59E+05	2.40E+04
SD11-1	60	995	1.15E+07	2.77E+00	1.09E+00	2.59E+05	4.00E+03
SD11-1	61	995	1.15E+07	2.77E+00	1.09E+00	2.63E+05	4.00E+03
SD11-1	62	995	1.15E+07	2.78E+00	1.09E+00	2.67E+05	4.00E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD11-1	63	995	1.15E+07	2.79E+00	1.09E+00	2.71E+05	4.00E+03
SD11-1	64	995	1.16E+07	2.80E+00	1.09E+00	2.75E+05	4.00E+03
SD11-1	65	995	1.16E+07	2.81E+00	1.09E+00	2.79E+05	4.00E+03
SD11-1	66	820	2.16E+03	9.25E-04	6.50E-01	2.83E+05	2.00E+04
SD11-1	67	821	1.79E+03	7.66E-04	6.50E-01	2.83E+05	2.00E+04
SD11-1	68	824	9.70E+02	4.15E-04	6.50E-01	2.83E+05	2.00E+04
SD11-1	69	995	1.16E+07	2.82E+00	1.09E+00	2.83E+05	4.00E+03
SD11-1	70	995	1.17E+07	2.83E+00	1.09E+00	2.87E+05	4.00E+03
SD11-1	71	995	1.17E+07	2.85E+00	1.09E+00	2.91E+05	4.00E+03
SD11-1	72	995	1.18E+07	2.86E+00	1.09E+00	2.95E+05	4.00E+03
SD11-1	73	995	1.19E+07	2.88E+00	1.09E+00	2.99E+05	4.00E+03
SD11-1	74	820	2.35E+03	9.90E-04	6.26E-01	3.03E+05	2.00E+04
SD11-1	75	821	1.95E+03	8.20E-04	6.26E-01	3.03E+05	2.00E+04
SD11-1	76	824	1.06E+03	4.44E-04	6.27E-01	3.03E+05	2.00E+04
SD11-1	77	995	1.19E+07	2.89E+00	1.09E+00	3.03E+05	4.00E+03
SD11-1	78	995	1.20E+07	2.90E+00	1.09E+00	3.07E+05	4.00E+03
SD11-1	79	995	1.20E+07	2.92E+00	1.09E+00	3.11E+05	4.00E+03
SD11-1	80	995	1.21E+07	2.93E+00	1.08E+00	3.15E+05	4.00E+03
SD11-1	81	995	1.21E+07	2.95E+00	1.08E+00	3.19E+05	4.00E+03
SD11-1	82	820	2.56E+03	1.06E-03	6.02E-01	3.23E+05	2.40E+04
SD11-1	83	821	2.13E+03	8.79E-04	6.03E-01	3.23E+05	2.40E+04
SD11-1	84	824	1.15E+03	4.77E-04	6.03E-01	3.23E+05	2.40E+04
SD11-1	85	995	1.22E+07	2.97E+00	1.08E+00	3.23E+05	4.00E+03
SD11-1	86	995	1.23E+07	2.98E+00	1.08E+00	3.27E+05	4.00E+03
SD11-1	87	995	1.23E+07	3.00E+00	1.08E+00	3.31E+05	4.00E+03
SD11-1	88	995	1.24E+07	3.02E+00	1.08E+00	3.35E+05	4.00E+03
SD11-1	89	995	1.25E+07	3.03E+00	1.08E+00	3.39E+05	4.00E+03
SD11-1	90	995	1.25E+07	3.05E+00	1.08E+00	3.43E+05	4.00E+03
SD11-1	91	820	2.78E+03	1.13E-03	5.81E-01	3.47E+05	2.00E+04
SD11-1	92	821	2.31E+03	9.38E-04	5.81E-01	3.47E+05	2.00E+04
SD11-1	93	824	1.25E+03	5.09E-04	5.81E-01	3.47E+05	2.00E+04
SD11-1	94	995	1.26E+07	3.06E+00	1.08E+00	3.47E+05	4.00E+03
SD11-1	95	995	1.26E+07	3.08E+00	1.08E+00	3.51E+05	4.00E+03
SD11-1	96	995	1.27E+07	3.10E+00	1.08E+00	3.55E+05	4.00E+03
SD11-1	97	995	1.28E+07	3.11E+00	1.08E+00	3.59E+05	4.00E+03
SD11-1	98	995	1.28E+07	3.13E+00	1.08E+00	3.63E+05	4.00E+03
SD11-1	99	820	3.01E+03	1.20E-03	5.62E-01	3.67E+05	2.40E+04
SD11-1	100	821	2.49E+03	9.98E-04	5.62E-01	3.67E+05	2.40E+04
SD11-1	101	824	1.35E+03	5.41E-04	5.62E-01	3.67E+05	2.40E+04
SD11-1	102	995	1.29E+07	3.15E+00	1.08E+00	3.67E+05	4.00E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD11-1	103	995	1.30E+07	3.16E+00	1.08E+00	3.71E+05	4.00E+03
SD11-1	104	995	1.30E+07	3.18E+00	1.08E+00	3.75E+05	4.00E+03
SD11-1	105	995	1.31E+07	3.19E+00	1.07E+00	3.79E+05	4.00E+03
SD11-1	106	995	1.32E+07	3.21E+00	1.07E+00	3.83E+05	4.00E+03
SD11-1	107	995	1.32E+07	3.23E+00	1.07E+00	3.87E+05	4.00E+03
SD11-1	108	820	3.24E+03	1.28E-03	5.46E-01	3.91E+05	2.00E+04
SD11-1	109	821	2.68E+03	1.06E-03	5.46E-01	3.91E+05	2.00E+04
SD11-1	110	824	1.46E+03	5.74E-04	5.46E-01	3.91E+05	2.00E+04
SD11-1	111	995	1.33E+07	3.24E+00	1.07E+00	3.91E+05	4.00E+03
SD11-1	112	995	1.34E+07	3.26E+00	1.07E+00	3.95E+05	4.00E+03
SD11-1	113	995	1.34E+07	3.27E+00	1.07E+00	3.99E+05	4.00E+03
SD11-1	114	995	1.35E+07	3.29E+00	1.07E+00	4.03E+05	4.00E+03
SD11-1	115	995	1.35E+07	3.31E+00	1.07E+00	4.07E+05	4.00E+03
SD11-1	116	820	3.45E+03	1.35E-03	5.34E-01	4.11E+05	2.00E+04
SD11-1	117	821	2.86E+03	1.12E-03	5.34E-01	4.11E+05	2.00E+04
SD11-1	118	824	1.55E+03	6.05E-04	5.34E-01	4.11E+05	2.00E+04
SD11-1	119	995	1.36E+07	3.32E+00	1.07E+00	4.11E+05	4.00E+03
SD11-1	120	995	1.37E+07	3.33E+00	1.07E+00	4.15E+05	4.00E+03
SD11-1	121	995	1.37E+07	3.35E+00	1.07E+00	4.19E+05	4.00E+03
SD11-1	122	995	1.38E+07	3.37E+00	1.07E+00	4.23E+05	4.00E+03
SD11-1	123	995	1.39E+07	3.39E+00	1.07E+00	4.27E+05	4.00E+03
SD11-1	124	820	3.71E+03	1.43E-03	5.23E-01	4.31E+05	2.40E+04
SD11-1	125	821	3.08E+03	1.18E-03	5.23E-01	4.31E+05	2.40E+04
SD11-1	126	824	1.67E+03	6.41E-04	5.23E-01	4.31E+05	2.40E+04
SD11-1	127	995	1.39E+07	3.40E+00	1.07E+00	4.31E+05	4.00E+03
SD11-1	128	995	1.40E+07	3.42E+00	1.07E+00	4.35E+05	4.00E+03
SD11-1	129	995	1.41E+07	3.43E+00	1.07E+00	4.39E+05	4.00E+03
SD11-1	130	995	1.41E+07	3.44E+00	1.07E+00	4.43E+05	4.00E+03
SD11-1	131	995	1.42E+07	3.45E+00	1.07E+00	4.47E+05	4.00E+03
SD11-1	132	995	1.42E+07	3.46E+00	1.06E+00	4.51E+05	4.00E+03
SD11-1	133	820	3.99E+03	1.52E-03	5.16E-01	4.55E+05	2.00E+04
SD11-1	134	821	3.30E+03	1.26E-03	5.16E-01	4.55E+05	2.00E+04
SD11-1	135	824	1.79E+03	6.82E-04	5.16E-01	4.55E+05	2.00E+04
SD11-1	136	995	1.42E+07	3.47E+00	1.06E+00	4.55E+05	4.00E+03
SD11-1	137	995	1.43E+07	3.48E+00	1.06E+00	4.59E+05	4.00E+03
SD11-1	138	995	1.43E+07	3.49E+00	1.06E+00	4.63E+05	4.00E+03
SD11-1	139	995	1.43E+07	3.50E+00	1.06E+00	4.67E+05	4.00E+03
SD11-1	140	995	1.44E+07	3.51E+00	1.06E+00	4.71E+05	4.00E+03
SD11-1	141	820	4.27E+03	1.61E-03	5.10E-01	4.75E+05	2.40E+04
SD11-1	142	821	3.54E+03	1.33E-03	5.10E-01	4.75E+05	2.40E+04

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD11-1	143	824	1.92E+03	7.23E-04	5.10E-01	4.75E+05	2.40E+04
SD11-1	144	995	1.44E+07	3.52E+00	1.06E+00	4.75E+05	4.00E+03
SD11-1	145	995	1.45E+07	3.53E+00	1.06E+00	4.79E+05	4.00E+03
SD11-1	146	995	1.45E+07	3.54E+00	1.06E+00	4.83E+05	4.00E+03
SD11-1	147	995	1.46E+07	3.56E+00	1.06E+00	4.87E+05	4.00E+03
SD11-1	148	995	1.46E+07	3.57E+00	1.06E+00	4.91E+05	4.00E+03
SD11-1	149	995	1.47E+07	3.58E+00	1.06E+00	4.95E+05	4.00E+03
SD11-1	150	820	4.55E+03	1.70E-03	5.04E-01	4.99E+05	2.00E+04
SD11-1	151	821	3.77E+03	1.41E-03	5.05E-01	4.99E+05	2.00E+04
SD11-1	152	824	2.05E+03	7.63E-04	5.05E-01	4.99E+05	2.00E+04
SD11-1	153	995	1.47E+07	3.60E+00	1.06E+00	4.99E+05	4.00E+03
SD11-1	154	995	1.48E+07	3.61E+00	1.06E+00	5.03E+05	4.00E+03
SD11-1	155	995	1.48E+07	3.62E+00	1.06E+00	5.07E+05	4.00E+03
SD11-1	156	995	1.49E+07	3.63E+00	1.06E+00	5.11E+05	4.00E+03
SD11-1	157	995	1.49E+07	3.64E+00	1.06E+00	5.15E+05	4.00E+03
SD11-1	158	820	4.80E+03	1.78E-03	5.00E-01	5.19E+05	2.00E+04
SD11-1	159	821	3.98E+03	1.47E-03	5.01E-01	5.19E+05	2.00E+04
SD11-1	160	824	2.16E+03	8.00E-04	5.01E-01	5.19E+05	2.00E+04
SD11-1	161	995	1.50E+07	3.65E+00	1.06E+00	5.19E+05	4.00E+03
SD11-1	162	995	1.50E+07	3.66E+00	1.06E+00	5.23E+05	4.00E+03
SD11-1	163	995	1.50E+07	3.67E+00	1.06E+00	5.27E+05	4.00E+03
SD11-1	164	995	1.51E+07	3.68E+00	1.06E+00	5.31E+05	4.00E+03
SD11-1	165	995	1.51E+07	3.70E+00	1.06E+00	5.35E+05	4.00E+03
SD11-1	166	820	5.08E+03	1.87E-03	4.96E-01	5.39E+05	2.40E+04
SD11-1	167	821	4.21E+03	1.55E-03	4.96E-01	5.39E+05	2.40E+04
SD11-1	168	824	2.28E+03	8.39E-04	4.96E-01	5.39E+05	2.40E+04
SD11-1	169	995	1.52E+07	3.71E+00	1.06E+00	5.39E+05	4.00E+03
SD11-1	170	995	1.52E+07	3.71E+00	1.06E+00	5.43E+05	4.00E+03
SD11-1	171	995	1.52E+07	3.72E+00	1.05E+00	5.47E+05	4.00E+03
SD11-1	172	995	1.53E+07	3.73E+00	1.05E+00	5.51E+05	4.00E+03
SD11-1	173	995	1.53E+07	3.74E+00	1.05E+00	5.55E+05	4.00E+03
SD11-1	174	995	1.54E+07	3.75E+00	1.05E+00	5.59E+05	4.00E+03
SD11-1	175	820	5.35E+03	1.95E-03	4.92E-01	5.63E+05	2.00E+04
SD11-1	176	821	4.44E+03	1.62E-03	4.92E-01	5.63E+05	2.00E+04
SD11-1	177	824	2.41E+03	8.79E-04	4.92E-01	5.63E+05	2.00E+04
SD11-1	178	995	1.54E+07	3.76E+00	1.05E+00	5.63E+05	4.00E+03
SD11-1	179	995	1.54E+07	3.77E+00	1.05E+00	5.67E+05	4.00E+03
SD11-1	180	995	1.55E+07	3.78E+00	1.05E+00	5.71E+05	4.00E+03
SD11-1	181	995	1.55E+07	3.79E+00	1.05E+00	5.75E+05	4.00E+03
SD11-1	182	995	1.56E+07	3.80E+00	1.05E+00	5.79E+05	4.00E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD11-1	183	820	5.63E+03	2.04E-03	4.88E-01	5.83E+05	2.40E+04
SD11-1	184	821	4.67E+03	1.70E-03	4.88E-01	5.83E+05	2.40E+04
SD11-1	185	824	2.53E+03	9.20E-04	4.88E-01	5.83E+05	2.40E+04
SD11-1	186	995	1.56E+07	3.80E+00	1.05E+00	5.83E+05	4.00E+03
SD11-1	187	995	1.56E+07	3.81E+00	1.05E+00	5.87E+05	4.00E+03
SD11-1	188	995	1.57E+07	3.82E+00	1.05E+00	5.91E+05	4.00E+03
SD11-1	189	995	1.57E+07	3.83E+00	1.05E+00	5.95E+05	4.00E+03
SD11-1	190	995	1.57E+07	3.84E+00	1.05E+00	5.99E+05	4.00E+03
SD11-1	191	995	1.57E+07	3.84E+00	1.05E+00	6.03E+05	4.00E+03
SD11-1	192	820	5.92E+03	2.14E-03	4.85E-01	6.07E+05	2.00E+04
SD11-1	193	821	4.91E+03	1.77E-03	4.85E-01	6.07E+05	2.00E+04
SD11-1	194	824	2.66E+03	9.61E-04	4.85E-01	6.07E+05	2.00E+04
SD11-1	195	995	1.58E+07	3.85E+00	1.05E+00	6.07E+05	4.00E+03
SD11-1	196	995	1.58E+07	3.86E+00	1.05E+00	6.11E+05	4.00E+03
SD11-1	197	995	1.58E+07	3.86E+00	1.05E+00	6.15E+05	4.00E+03
SD11-1	198	995	1.59E+07	3.87E+00	1.05E+00	6.19E+05	4.00E+03
SD11-1	199	995	1.59E+07	3.88E+00	1.05E+00	6.23E+05	4.00E+03
SD11-1	200	820	6.18E+03	2.22E-03	4.81E-01	6.27E+05	2.08E+04
SD11-1	201	821	5.13E+03	1.84E-03	4.82E-01	6.27E+05	2.08E+04
SD11-1	202	824	2.78E+03	1.00E-03	4.82E-01	6.27E+05	2.08E+04
SD11-1	203	995	1.59E+07	3.89E+00	1.05E+00	6.27E+05	4.00E+03
SD11-1	204	995	1.60E+07	3.90E+00	1.05E+00	6.31E+05	4.00E+03
SD11-1	205	995	1.60E+07	3.90E+00	1.05E+00	6.35E+05	4.00E+03
SD11-1	206	995	1.60E+07	3.91E+00	1.05E+00	6.39E+05	4.00E+03
SD11-1	207	995	1.61E+07	3.92E+00	1.05E+00	6.43E+05	4.80E+03
SD12	1	820	1.10E+03	2.67E-04	1.04E+00	1.91E+06	2.15E+04
SD12	2	821	9.17E+02	2.23E-04	1.04E+00	1.91E+06	2.15E+04
SD12	3	824	5.29E+02	1.28E-04	1.04E+00	1.91E+06	2.15E+04
SD12	4	27	3.55E+06	8.39E-01	1.17E+00	1.94E+06	3.50E+03
SD12	5	820	1.11E+03	2.83E-04	1.02E+00	1.94E+06	2.15E+04
SD12	6	821	9.19E+02	2.34E-04	1.02E+00	1.94E+06	2.15E+04
SD12	7	824	5.23E+02	1.34E-04	1.03E+00	1.94E+06	2.15E+04
SD12	8	27	3.54E+06	8.38E-01	1.17E+00	1.94E+06	4.00E+03
SD12	9	27	3.54E+06	8.37E-01	1.17E+00	1.94E+06	3.50E+03
SD12	10	27	3.54E+06	8.37E-01	1.17E+00	1.95E+06	3.50E+03
SD12	11	27	3.55E+06	8.39E-01	1.17E+00	1.95E+06	3.50E+03
SD12	12	27	3.55E+06	8.40E-01	1.17E+00	1.95E+06	3.50E+03
SD12	13	27	3.54E+06	8.39E-01	1.17E+00	1.96E+06	3.92E+03
SD12	14	820	1.08E+03	2.75E-04	1.03E+00	1.96E+06	2.17E+04
SD12	15	821	8.92E+02	2.27E-04	1.03E+00	1.96E+06	2.17E+04

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD12	16	824	5.13E+02	1.31E-04	1.03E+00	1.96E+06	2.17E+04
SD12	17	27	3.54E+06	8.38E-01	1.17E+00	1.96E+06	3.58E+03
SD12	18	27	3.54E+06	8.38E-01	1.17E+00	1.97E+06	3.50E+03
SD12	19	27	3.54E+06	8.38E-01	1.17E+00	1.97E+06	3.50E+03
SD12	20	27	3.54E+06	8.38E-01	1.17E+00	1.97E+06	3.50E+03
SD12	21	27	3.54E+06	8.38E-01	1.17E+00	1.98E+06	3.71E+03
SD12	22	27	3.54E+06	8.39E-01	1.17E+00	1.98E+06	3.79E+03
SD12	23	820	1.13E+03	2.88E-04	1.01E+00	1.98E+06	2.18E+04
SD12	24	821	9.33E+02	2.38E-04	1.01E+00	1.98E+06	2.18E+04
SD12	25	824	5.33E+02	1.36E-04	1.01E+00	1.98E+06	2.18E+04
SD12	26	27	3.54E+06	8.38E-01	1.17E+00	1.98E+06	3.50E+03
SD12	27	27	3.54E+06	8.38E-01	1.17E+00	1.99E+06	3.50E+03
SD12	28	27	3.54E+06	8.38E-01	1.17E+00	1.99E+06	3.50E+03
SD12	29	27	3.54E+06	8.38E-01	1.17E+00	1.99E+06	4.00E+03
SD12	30	27	3.52E+06	8.35E-01	1.17E+00	2.00E+06	3.50E+03
SD12	31	27	3.56E+06	8.44E-01	1.17E+00	2.00E+06	3.50E+03
SD12	32	820	6.61E+02	1.95E-04	1.05E+00	2.00E+06	2.15E+04
SD12	33	821	5.61E+02	1.65E-04	1.05E+00	2.00E+06	2.15E+04
SD12	34	824	3.33E+02	9.81E-05	1.05E+00	2.00E+06	2.15E+04
SD12	35	27	3.54E+06	8.39E-01	1.17E+00	2.00E+06	3.50E+03
SD12	36	27	3.54E+06	8.37E-01	1.17E+00	2.01E+06	3.50E+03
SD12	37	27	3.53E+06	8.37E-01	1.17E+00	2.01E+06	4.00E+03
SD12	38	27	3.53E+06	8.37E-01	1.17E+00	2.02E+06	3.50E+03
SD12	39	27	3.53E+06	8.36E-01	1.17E+00	2.02E+06	3.50E+03
SD12	40	27	3.53E+06	8.36E-01	1.17E+00	2.02E+06	3.60E+03
SD12	41	820	7.07E+02	2.08E-04	1.05E+00	2.02E+06	2.16E+04
SD12	42	821	6.01E+02	1.77E-04	1.05E+00	2.02E+06	2.16E+04
SD12	43	824	3.57E+02	1.05E-04	1.05E+00	2.02E+06	2.16E+04
SD12	44	27	3.53E+06	8.36E-01	1.17E+00	2.03E+06	3.60E+03
SD12	45	27	3.53E+06	8.37E-01	1.17E+00	2.03E+06	3.60E+03
SD12	46	27	3.53E+06	8.37E-01	1.17E+00	2.03E+06	3.60E+03
SD12	47	27	3.53E+06	8.37E-01	1.17E+00	2.04E+06	3.60E+03
SD12	48	27	3.53E+06	8.37E-01	1.17E+00	2.04E+06	3.60E+03
SD12	49	27	3.53E+06	8.37E-01	1.17E+00	2.04E+06	3.60E+03
SD12	50	820	7.80E+02	2.30E-04	1.03E+00	2.04E+06	2.16E+04
SD12	51	821	6.56E+02	1.93E-04	1.03E+00	2.04E+06	2.16E+04
SD12	52	824	3.90E+02	1.15E-04	1.04E+00	2.04E+06	2.16E+04
SD12	53	27	3.53E+06	8.37E-01	1.17E+00	2.05E+06	3.60E+03
SD12	54	27	3.53E+06	8.37E-01	1.17E+00	2.05E+06	3.60E+03
SD12	55	27	3.53E+06	8.37E-01	1.17E+00	2.06E+06	3.60E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD12	56	27	3.53E+06	8.37E-01	1.17E+00	2.06E+06	3.60E+03
SD12	57	27	3.53E+06	8.37E-01	1.17E+00	2.06E+06	3.60E+03
SD12	58	27	3.53E+06	8.37E-01	1.17E+00	2.07E+06	3.60E+03
SD12	59	820	8.27E+02	2.43E-04	1.03E+00	2.07E+06	2.16E+04
SD12	60	821	6.86E+02	2.02E-04	1.03E+00	2.07E+06	2.16E+04
SD12	61	824	4.06E+02	1.19E-04	1.03E+00	2.07E+06	2.16E+04
SD12	62	27	3.53E+06	8.37E-01	1.17E+00	2.07E+06	3.60E+03
SD12	63	27	3.53E+06	8.37E-01	1.17E+00	2.07E+06	3.60E+03
SD12	64	27	3.53E+06	8.37E-01	1.17E+00	2.08E+06	3.60E+03
SD12	65	27	3.53E+06	8.37E-01	1.17E+00	2.08E+06	3.60E+03
SD12	66	27	3.53E+06	8.37E-01	1.17E+00	2.08E+06	3.60E+03
SD12	67	27	3.53E+06	8.37E-01	1.17E+00	2.09E+06	3.60E+03
SD12	68	820	8.78E+02	2.58E-04	1.02E+00	2.09E+06	2.16E+04
SD12	69	821	7.26E+02	2.13E-04	1.02E+00	2.09E+06	2.16E+04
SD12	70	824	4.25E+02	1.25E-04	1.02E+00	2.09E+06	2.16E+04
SD12	71	27	3.53E+06	8.37E-01	1.17E+00	2.09E+06	3.60E+03
SD12	72	27	3.53E+06	8.38E-01	1.17E+00	2.09E+06	3.60E+03
SD12	73	27	3.53E+06	8.38E-01	1.17E+00	2.10E+06	3.60E+03
SD12	74	27	3.53E+06	8.38E-01	1.17E+00	2.10E+06	3.60E+03
SD12	75	27	3.53E+06	8.38E-01	1.17E+00	2.11E+06	3.60E+03
SD12	76	27	3.53E+06	8.38E-01	1.17E+00	2.11E+06	3.60E+03
SD12	77	820	9.29E+02	2.73E-04	1.00E+00	2.11E+06	2.16E+04
SD12	78	821	7.68E+02	2.25E-04	1.00E+00	2.11E+06	2.16E+04
SD12	79	824	4.42E+02	1.30E-04	1.01E+00	2.11E+06	2.16E+04
SD12	80	27	3.54E+06	8.38E-01	1.17E+00	2.11E+06	3.60E+03
SD12	81	27	3.54E+06	8.38E-01	1.17E+00	2.12E+06	3.60E+03
SD12	82	27	3.53E+06	8.37E-01	1.17E+00	2.12E+06	3.60E+03
SD12	83	27	3.53E+06	8.37E-01	1.17E+00	2.12E+06	3.60E+03
SD12	84	27	3.53E+06	8.38E-01	1.17E+00	2.13E+06	3.60E+03
SD12	85	27	3.53E+06	8.38E-01	1.17E+00	2.13E+06	3.60E+03
SD12	86	820	7.94E+02	2.52E-04	9.81E-01	2.13E+06	2.16E+04
SD12	87	821	6.62E+02	2.11E-04	9.82E-01	2.13E+06	2.16E+04
SD12	88	824	3.80E+02	1.21E-04	9.88E-01	2.13E+06	2.16E+04
SD12	89	27	3.53E+06	8.38E-01	1.17E+00	2.13E+06	3.60E+03
SD12	90	27	3.53E+06	8.38E-01	1.17E+00	2.14E+06	3.60E+03
SD12	91	27	3.53E+06	8.37E-01	1.17E+00	2.14E+06	3.60E+03
SD12	92	27	3.55E+06	8.42E-01	1.17E+00	2.15E+06	3.60E+03
SD12	93	27	3.53E+06	8.38E-01	1.17E+00	2.15E+06	3.60E+03
SD12	94	27	3.53E+06	8.36E-01	1.17E+00	2.15E+06	3.60E+03
SD12	95	820	3.24E+02	1.28E-04	1.06E+00	2.15E+06	2.16E+04

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD12	96	821	2.77E+02	1.09E-04	1.06E+00	2.15E+06	2.16E+04
SD12	97	824	1.66E+02	6.58E-05	1.06E+00	2.15E+06	2.16E+04
SD12	98	27	3.53E+06	8.36E-01	1.17E+00	2.16E+06	3.60E+03
SD12	99	27	3.53E+06	8.36E-01	1.17E+00	2.16E+06	3.60E+03
SD12	100	27	3.52E+06	8.35E-01	1.17E+00	2.16E+06	3.60E+03
SD12	101	27	3.52E+06	8.35E-01	1.17E+00	2.17E+06	3.60E+03
SD12	102	27	3.52E+06	8.35E-01	1.17E+00	2.17E+06	3.60E+03
SD12	103	27	3.52E+06	8.35E-01	1.17E+00	2.17E+06	3.60E+03
SD12	104	820	3.56E+02	1.41E-04	1.05E+00	2.17E+06	2.16E+04
SD12	105	821	3.04E+02	1.20E-04	1.05E+00	2.17E+06	2.16E+04
SD12	106	824	1.82E+02	7.20E-05	1.05E+00	2.17E+06	2.16E+04
SD12	107	27	3.52E+06	8.35E-01	1.17E+00	2.18E+06	3.60E+03
SD12	108	27	3.53E+06	8.35E-01	1.17E+00	2.18E+06	3.60E+03
SD12	109	27	3.53E+06	8.36E-01	1.17E+00	2.18E+06	3.60E+03
SD12	110	27	3.53E+06	8.36E-01	1.17E+00	2.19E+06	3.60E+03
SD12	111	27	3.53E+06	8.36E-01	1.17E+00	2.19E+06	3.60E+03
SD12	112	27	3.53E+06	8.36E-01	1.17E+00	2.20E+06	3.60E+03
SD12	113	820	4.05E+02	1.60E-04	1.04E+00	2.20E+06	2.17E+04
SD12	114	821	3.45E+02	1.36E-04	1.04E+00	2.20E+06	2.17E+04
SD12	115	824	2.07E+02	8.15E-05	1.04E+00	2.20E+06	2.17E+04
SD12	116	27	3.53E+06	8.36E-01	1.17E+00	2.20E+06	3.60E+03
SD12	117	27	3.53E+06	8.36E-01	1.17E+00	2.20E+06	3.68E+03
SD12	118	27	3.53E+06	8.36E-01	1.17E+00	2.21E+06	3.32E+03
SD12	119	27	3.53E+06	8.36E-01	1.17E+00	2.21E+06	4.00E+03
SD12	120	27	3.53E+06	8.36E-01	1.17E+00	2.21E+06	3.50E+03
SD12	121	27	3.53E+06	8.36E-01	1.17E+00	2.22E+06	4.00E+03
SD12	122	820	4.49E+02	1.77E-04	1.03E+00	2.22E+06	2.20E+04
SD12	123	821	3.83E+02	1.51E-04	1.03E+00	2.22E+06	2.20E+04
SD12	124	824	2.29E+02	9.01E-05	1.03E+00	2.22E+06	2.20E+04
SD12	125	27	3.53E+06	8.36E-01	1.17E+00	2.22E+06	4.00E+03
SD12	126	27	3.53E+06	8.36E-01	1.17E+00	2.23E+06	2.00E+03
SD12	127	27	3.53E+06	8.36E-01	1.17E+00	2.23E+06	4.00E+03
SD12	128	27	3.53E+06	8.36E-01	1.17E+00	2.23E+06	4.00E+03
SD12	129	27	3.53E+06	8.36E-01	1.17E+00	2.24E+06	4.00E+03
SD12	130	27	3.53E+06	8.36E-01	1.17E+00	2.24E+06	3.00E+03
SD12	131	820	4.89E+02	1.92E-04	1.02E+00	2.24E+06	2.20E+04
SD12	132	821	4.17E+02	1.64E-04	1.02E+00	2.24E+06	2.20E+04
SD12	133	824	2.48E+02	9.77E-05	1.02E+00	2.24E+06	2.20E+04
SD12	134	27	3.53E+06	8.36E-01	1.17E+00	2.24E+06	3.50E+03
SD12	135	27	3.53E+06	8.36E-01	1.17E+00	2.25E+06	3.50E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD12	136	27	3.53E+06	8.36E-01	1.17E+00	2.25E+06	4.00E+03
SD12	137	27	3.53E+06	8.36E-01	1.17E+00	2.25E+06	4.00E+03
SD12	138	27	3.53E+06	8.36E-01	1.17E+00	2.26E+06	4.00E+03
SD12	139	27	3.53E+06	8.36E-01	1.17E+00	2.26E+06	2.00E+03
SD12	140	820	5.22E+02	2.05E-04	1.01E+00	2.26E+06	2.00E+04
SD12	141	821	4.45E+02	1.75E-04	1.01E+00	2.26E+06	2.00E+04
SD12	142	824	2.65E+02	1.04E-04	1.01E+00	2.26E+06	2.00E+04
SD12	143	27	3.53E+06	8.36E-01	1.17E+00	2.26E+06	4.00E+03
SD12	144	27	3.53E+06	8.36E-01	1.17E+00	2.27E+06	4.00E+03
SD12	145	27	3.53E+06	8.36E-01	1.17E+00	2.27E+06	4.00E+03
SD12	146	27	3.53E+06	8.36E-01	1.17E+00	2.28E+06	4.00E+03
SD12	147	27	3.53E+06	8.37E-01	1.17E+00	2.28E+06	2.00E+03
SD12	148	27	3.53E+06	8.37E-01	1.17E+00	2.28E+06	4.00E+03
SD12	149	820	5.54E+02	2.17E-04	9.99E-01	2.28E+06	2.20E+04
SD12	150	821	4.70E+02	1.84E-04	9.99E-01	2.28E+06	2.20E+04
SD12	151	824	2.79E+02	1.10E-04	1.00E+00	2.28E+06	2.20E+04
SD12	152	27	3.53E+06	8.37E-01	1.17E+00	2.29E+06	4.00E+03
SD12	153	27	3.53E+06	8.37E-01	1.17E+00	2.29E+06	4.00E+03
SD12	154	27	3.53E+06	8.37E-01	1.17E+00	2.29E+06	4.00E+03
SD12	155	27	3.53E+06	8.37E-01	1.17E+00	2.30E+06	2.00E+03
SD12	156	27	3.53E+06	8.37E-01	1.17E+00	2.30E+06	4.00E+03
SD12	157	27	3.53E+06	8.37E-01	1.17E+00	2.30E+06	4.00E+03
SD12	158	820	2.21E+02	9.74E-05	9.22E-01	2.30E+06	2.20E+04
SD12	159	821	1.86E+02	8.26E-05	9.29E-01	2.30E+06	2.20E+04
SD12	160	824	1.08E+02	4.80E-05	9.34E-01	2.30E+06	2.20E+04
SD12	161	27	3.53E+06	8.38E-01	1.17E+00	2.31E+06	4.00E+03
SD12	162	27	3.54E+06	8.39E-01	1.17E+00	2.31E+06	4.00E+03
SD12	163	27	3.53E+06	8.36E-01	1.17E+00	2.32E+06	2.00E+03
SD12	164	27	3.52E+06	8.35E-01	1.17E+00	2.32E+06	4.00E+03
SD12	165	27	3.52E+06	8.35E-01	1.17E+00	2.32E+06	4.00E+03
SD12	166	27	3.52E+06	8.34E-01	1.17E+00	2.33E+06	4.00E+03
SD12	167	27	3.52E+06	8.34E-01	1.17E+00	2.33E+06	4.00E+03
SD12	168	27	3.52E+06	8.34E-01	1.17E+00	2.33E+06	2.00E+03
SD12	169	27	3.52E+06	8.34E-01	1.17E+00	2.34E+06	4.00E+03
SD12	170	27	3.52E+06	8.34E-01	1.17E+00	2.34E+06	4.00E+03
SD12	171	27	3.52E+06	8.34E-01	1.17E+00	2.34E+06	4.00E+03
SD12	172	27	3.52E+06	8.34E-01	1.17E+00	2.35E+06	4.00E+03
SD12	173	27	3.52E+06	8.34E-01	1.17E+00	2.35E+06	2.00E+03
SD12	174	27	3.52E+06	8.34E-01	1.17E+00	2.35E+06	4.00E+03
SD12	175	27	3.52E+06	8.34E-01	1.17E+00	2.36E+06	4.00E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD12	176	27	3.52E+06	8.34E-01	1.17E+00	2.36E+06	4.00E+03
SD12	177	27	3.52E+06	8.34E-01	1.17E+00	2.37E+06	4.00E+03
SD12	178	27	3.52E+06	8.35E-01	1.17E+00	2.37E+06	2.00E+03
SD12	179	820	1.70E+01	1.04E-05	1.03E+00	2.37E+06	2.00E+04
SD12	180	821	1.15E+01	7.07E-06	1.03E+00	2.37E+06	2.00E+04
SD12	181	824	4.56E+00	2.80E-06	1.03E+00	2.37E+06	2.00E+04
SD12	182	27	3.52E+06	8.35E-01	1.17E+00	2.37E+06	4.00E+03
SD12	183	27	3.52E+06	8.35E-01	1.17E+00	2.38E+06	4.00E+03
SD12	184	27	3.52E+06	8.35E-01	1.17E+00	2.38E+06	4.00E+03
SD12	185	27	3.52E+06	8.35E-01	1.17E+00	2.38E+06	4.00E+03
SD12	186	27	3.52E+06	8.35E-01	1.17E+00	2.39E+06	2.00E+03
SD12	187	27	3.52E+06	8.35E-01	1.17E+00	2.39E+06	4.00E+03
SD12	188	820	1.36E+02	8.35E-05	1.03E+00	2.39E+06	2.20E+04
SD12	189	821	1.10E+02	6.72E-05	1.03E+00	2.39E+06	2.20E+04
SD12	190	824	4.91E+01	3.01E-05	1.03E+00	2.39E+06	2.20E+04
SD12	191	27	3.52E+06	8.35E-01	1.17E+00	2.39E+06	4.00E+03
SD12	192	27	3.52E+06	8.35E-01	1.17E+00	2.40E+06	4.00E+03
SD12	193	27	3.52E+06	8.35E-01	1.17E+00	2.40E+06	4.00E+03
SD12	194	27	3.52E+06	8.35E-01	1.17E+00	2.41E+06	2.00E+03
SD12	195	27	3.52E+06	8.35E-01	1.17E+00	2.41E+06	4.00E+03
SD12	196	27	3.52E+06	8.35E-01	1.17E+00	2.41E+06	4.00E+03
SD12	197	820	1.93E+02	1.18E-04	1.02E+00	2.41E+06	1.88E+04
SD12	198	821	1.64E+02	1.00E-04	1.02E+00	2.41E+06	1.88E+04
SD12	199	824	9.58E+01	5.85E-05	1.02E+00	2.41E+06	1.88E+04
SD12	200	27	3.52E+06	8.35E-01	1.17E+00	2.42E+06	4.00E+03
SD12	201	27	3.52E+06	8.35E-01	1.17E+00	2.42E+06	4.00E+03
SD12	202	27	3.52E+06	8.35E-01	1.17E+00	2.42E+06	2.00E+03
SD12	203	27	3.52E+06	8.35E-01	1.17E+00	2.43E+06	4.80E+03
SD13	1	9609	1.11E+08	2.71E+01	9.97E-01	2.21E+05	3.60E+03
SD13	2	9609	1.13E+08	2.77E+01	9.84E-01	2.25E+05	3.63E+03
SD13	3	9609	1.10E+08	2.66E+01	9.93E-01	2.28E+05	3.57E+03
SD13	4	9609	1.08E+08	2.63E+01	1.00E+00	2.32E+05	3.50E+03
SD13	5	9609	1.05E+08	2.52E+01	1.01E+00	2.36E+05	3.51E+03
SD13	6	9609	9.87E+07	2.37E+01	1.03E+00	2.39E+05	3.79E+03
SD13	7	9609	1.09E+08	2.63E+01	9.95E-01	2.43E+05	3.68E+03
SD13	8	9599	4.19E+06	1.00E+00	1.03E+00	2.44E+05	3.40E+03
SD13	9	9609	9.67E+07	2.31E+01	1.03E+00	2.46E+05	3.52E+03
SD13	10	9599	1.67E+06	3.97E-01	1.02E+00	2.47E+05	3.80E+03
SD13	11	9609	9.61E+07	2.30E+01	1.01E+00	2.50E+05	3.60E+03
SD13	12	9599	1.38E+07	3.30E+00	1.01E+00	2.51E+05	3.60E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD13	13	9609	1.05E+08	2.51E+01	1.00E+00	2.54E+05	3.40E+03
SD13	14	9599	1.54E+05	3.69E-02	1.01E+00	2.54E+05	3.60E+03
SD13	15	9609	1.08E+08	2.54E+01	1.00E+00	2.57E+05	4.00E+03
SD13	16	9609	1.09E+08	2.55E+01	1.00E+00	2.61E+05	3.50E+03
SD13	17	9609	1.09E+08	2.56E+01	9.99E-01	2.65E+05	3.50E+03
SD13	18	9609	1.10E+08	2.58E+01	9.97E-01	2.68E+05	3.50E+03
SD13	19	9609	1.11E+08	2.59E+01	9.94E-01	2.72E+05	3.50E+03
SD13	20	9609	1.11E+08	2.61E+01	9.92E-01	2.75E+05	4.00E+03
SD13	21	9609	1.12E+08	2.62E+01	9.90E-01	2.79E+05	3.50E+03
SD13	22	9609	1.12E+08	2.63E+01	9.88E-01	2.83E+05	3.50E+03
SD13	23	9609	1.13E+08	2.64E+01	9.86E-01	2.86E+05	3.50E+03
SD13	24	9609	1.13E+08	2.65E+01	9.85E-01	2.90E+05	3.50E+03
SD13	25	9609	1.14E+08	2.66E+01	9.84E-01	2.93E+05	4.00E+03
SD13	26	9609	1.14E+08	2.67E+01	9.82E-01	2.97E+05	3.50E+03
SD13	27	9609	1.14E+08	2.67E+01	9.81E-01	3.01E+05	3.50E+03
SD13	28	9609	1.14E+08	2.68E+01	9.80E-01	3.04E+05	3.50E+03
SD13	29	9609	1.15E+08	2.68E+01	9.80E-01	3.08E+05	3.50E+03
SD13	30	9609	1.15E+08	2.69E+01	9.79E-01	3.11E+05	4.00E+03
SD13	31	9609	1.15E+08	2.69E+01	9.78E-01	3.15E+05	3.50E+03
SD13	32	9609	1.15E+08	2.70E+01	9.77E-01	3.19E+05	3.50E+03
SD13	33	9609	1.16E+08	2.70E+01	9.76E-01	3.22E+05	3.50E+03
SD13	34	9609	1.16E+08	2.71E+01	9.75E-01	3.26E+05	3.50E+03
SD13	35	9609	1.16E+08	2.71E+01	9.74E-01	3.29E+05	4.00E+03
SD13	36	9609	1.16E+08	2.72E+01	9.73E-01	3.33E+05	3.50E+03
SD13	37	9609	1.16E+08	2.72E+01	9.73E-01	3.37E+05	3.50E+03
SD13	38	9609	1.17E+08	2.73E+01	9.72E-01	3.40E+05	3.50E+03
SD13	39	9609	1.17E+08	2.75E+01	9.72E-01	3.44E+05	3.50E+03
SD13	40	9609	1.19E+08	2.78E+01	9.72E-01	3.47E+05	4.00E+03
SD13	41	9609	1.19E+08	2.78E+01	9.70E-01	3.51E+05	3.50E+03
SD13	42	9609	1.16E+08	2.71E+01	9.71E-01	3.55E+05	3.50E+03
SD13	43	9609	1.16E+08	2.71E+01	9.72E-01	3.58E+05	3.50E+03
SD13	44	9609	1.17E+08	2.72E+01	9.71E-01	3.62E+05	3.50E+03
SD13	45	9609	1.17E+08	2.72E+01	9.70E-01	3.65E+05	4.00E+03
SD13	46	9609	1.17E+08	2.73E+01	9.68E-01	3.69E+05	3.50E+03
SD13	47	9609	1.18E+08	2.74E+01	9.67E-01	3.73E+05	3.50E+03
SD13	48	9609	1.18E+08	2.74E+01	9.66E-01	3.76E+05	3.50E+03
SD13	49	9609	1.18E+08	2.75E+01	9.65E-01	3.80E+05	3.50E+03
SD13	50	9609	1.18E+08	2.75E+01	9.64E-01	3.83E+05	4.00E+03
SD13	51	9609	1.19E+08	2.76E+01	9.63E-01	3.87E+05	3.50E+03
SD13	52	9609	1.19E+08	2.76E+01	9.62E-01	3.91E+05	3.50E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD13	53	9609	1.19E+08	2.77E+01	9.61E-01	3.94E+05	3.50E+03
SD13	54	9609	1.19E+08	2.77E+01	9.60E-01	3.98E+05	3.70E+03
SD13	55	9609	1.20E+08	2.79E+01	9.58E-01	4.01E+05	3.20E+03
SD13	56	9609	1.20E+08	2.79E+01	9.58E-01	4.04E+05	4.00E+03
SD13	57	9609	1.20E+08	2.79E+01	9.57E-01	4.08E+05	3.20E+03
SD13	58	9609	1.20E+08	2.79E+01	9.57E-01	4.12E+05	4.00E+03
SD13	59	9609	1.20E+08	2.80E+01	9.56E-01	4.16E+05	3.20E+03
SD13	60	9609	1.21E+08	2.80E+01	9.55E-01	4.19E+05	4.00E+03
SD13	61	9609	1.21E+08	2.81E+01	9.54E-01	4.23E+05	3.20E+03
SD13	62	9609	1.21E+08	2.81E+01	9.53E-01	4.26E+05	4.00E+03
SD13	63	9609	1.26E+08	2.95E+01	9.40E-01	4.30E+05	3.20E+03
SD13	64	9609	1.22E+08	2.85E+01	9.44E-01	4.33E+05	4.00E+03
SD13	65	9609	1.21E+08	2.83E+01	9.50E-01	4.37E+05	3.20E+03
SD13	66	9609	1.21E+08	2.82E+01	9.51E-01	4.40E+05	4.00E+03
SD13	67	9609	1.22E+08	2.83E+01	9.50E-01	4.44E+05	4.00E+03
SD13	68	9609	1.22E+08	2.83E+01	9.50E-01	4.48E+05	3.20E+03
SD13	69	9609	1.22E+08	2.83E+01	9.49E-01	4.52E+05	3.20E+03
SD13	70	9609	1.22E+08	2.84E+01	9.49E-01	4.55E+05	4.00E+03
SD13	71	9609	1.22E+08	2.84E+01	9.48E-01	4.59E+05	3.20E+03
SD13	72	9609	1.22E+08	2.84E+01	9.47E-01	4.62E+05	4.00E+03
SD13	73	9609	1.23E+08	2.85E+01	9.47E-01	4.66E+05	3.20E+03
SD13	74	9609	1.23E+08	2.85E+01	9.46E-01	4.69E+05	4.00E+03
SD13	75	9609	1.23E+08	2.85E+01	9.45E-01	4.73E+05	3.20E+03
SD13	76	9609	1.23E+08	2.86E+01	9.45E-01	4.76E+05	4.00E+03
SD13	77	9609	1.23E+08	2.86E+01	9.44E-01	4.80E+05	3.20E+03
SD13	78	9609	1.23E+08	2.86E+01	9.44E-01	4.84E+05	4.00E+03
SD13	79	9609	1.23E+08	2.87E+01	9.43E-01	4.88E+05	3.20E+03
SD13	80	9609	1.23E+08	2.87E+01	9.43E-01	4.91E+05	4.00E+03
SD13	81	9609	1.24E+08	2.87E+01	9.42E-01	4.95E+05	3.20E+03
SD13	82	9609	1.24E+08	2.87E+01	9.42E-01	4.98E+05	4.00E+03
SD13	83	9609	1.24E+08	2.88E+01	9.41E-01	5.02E+05	3.20E+03
SD13	84	9609	1.24E+08	2.88E+01	9.41E-01	5.05E+05	4.00E+03
SD13	85	9609	1.24E+08	2.88E+01	9.41E-01	5.09E+05	3.20E+03
SD13	86	9609	1.24E+08	2.88E+01	9.40E-01	5.12E+05	4.00E+03
SD13	87	9609	1.24E+08	2.88E+01	9.40E-01	5.16E+05	3.20E+03
SD13	88	9609	1.24E+08	2.89E+01	9.39E-01	5.20E+05	4.00E+03
SD13	89	9609	1.25E+08	2.89E+01	9.38E-01	5.24E+05	3.20E+03
SD13	90	9609	1.25E+08	2.90E+01	9.38E-01	5.27E+05	4.00E+03
SD13	91	9609	1.25E+08	2.89E+01	9.38E-01	5.31E+05	3.20E+03
SD13	92	9609	1.25E+08	2.90E+01	9.38E-01	5.34E+05	4.00E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD13	93	9609	1.25E+08	2.90E+01	9.37E-01	5.38E+05	3.20E+03
SD13	94	9609	1.25E+08	2.90E+01	9.38E-01	5.41E+05	4.00E+03
SD13	95	9609	1.25E+08	2.90E+01	9.38E-01	5.45E+05	3.20E+03
SD13	96	9609	1.25E+08	2.90E+01	9.37E-01	5.48E+05	4.00E+03
SD13	97	9609	1.25E+08	2.90E+01	9.37E-01	5.52E+05	3.20E+03
SD13	98	9609	1.25E+08	2.90E+01	9.37E-01	5.56E+05	4.00E+03
SD13	99	9609	1.25E+08	2.90E+01	9.36E-01	5.60E+05	3.20E+03
SD13	100	9609	1.25E+08	2.91E+01	9.36E-01	5.63E+05	4.00E+03
SD13	101	9609	1.25E+08	2.91E+01	9.35E-01	5.67E+05	3.20E+03
SD13	102	9609	1.25E+08	2.91E+01	9.35E-01	5.70E+05	4.00E+03
SD13	103	9609	1.25E+08	2.91E+01	9.35E-01	5.74E+05	3.20E+03
SD13	104	9609	1.25E+08	2.91E+01	9.34E-01	5.77E+05	4.00E+03
SD13	105	9609	1.26E+08	2.92E+01	9.34E-01	5.81E+05	3.20E+03
SD13	106	9609	1.26E+08	2.92E+01	9.34E-01	5.84E+05	4.00E+03
SD13	107	9609	1.26E+08	2.92E+01	9.33E-01	5.88E+05	3.20E+03
SD13	108	9609	1.26E+08	2.93E+01	9.31E-01	5.92E+05	4.00E+03
SD13	109	9609	1.26E+08	2.93E+01	9.31E-01	5.96E+05	3.20E+03
SD13	110	9609	1.26E+08	2.93E+01	9.30E-01	5.99E+05	4.00E+03
SD13	111	9609	1.27E+08	2.94E+01	9.30E-01	6.03E+05	3.20E+03
SD13	112	9609	1.27E+08	2.94E+01	9.29E-01	6.06E+05	4.00E+03
SD13	113	9609	1.27E+08	2.94E+01	9.28E-01	6.10E+05	3.20E+03
SD13	114	9609	1.27E+08	2.94E+01	9.29E-01	6.13E+05	4.00E+03
SD13	115	9609	1.27E+08	2.94E+01	9.30E-01	6.17E+05	3.20E+03
SD13	116	9609	1.27E+08	2.95E+01	9.28E-01	6.20E+05	4.00E+03
SD13	117	9609	1.27E+08	2.95E+01	9.27E-01	6.24E+05	3.20E+03
SD13	118	9609	1.27E+08	2.95E+01	9.28E-01	6.28E+05	4.00E+03
SD13	119	9609	1.27E+08	2.94E+01	9.28E-01	6.32E+05	3.20E+03
SD13	120	9609	1.27E+08	2.95E+01	9.28E-01	6.35E+05	4.00E+03
SD13	121	9609	1.27E+08	2.95E+01	9.27E-01	6.39E+05	3.20E+03
SD13	122	9609	1.27E+08	2.95E+01	9.27E-01	6.42E+05	4.00E+03
SD13	123	9609	1.27E+08	2.95E+01	9.27E-01	6.46E+05	3.20E+03
SD13	124	9609	1.27E+08	2.96E+01	9.26E-01	6.49E+05	4.00E+03
SD13	125	9609	1.27E+08	2.96E+01	9.25E-01	6.53E+05	3.20E+03
SD13	126	9609	1.27E+08	2.96E+01	9.26E-01	6.56E+05	4.00E+03
SD13	127	9609	1.27E+08	2.95E+01	9.26E-01	6.60E+05	3.20E+03
SD13	128	9609	1.27E+08	2.96E+01	9.26E-01	6.64E+05	4.00E+03
SD13	129	9609	1.27E+08	2.96E+01	9.26E-01	6.68E+05	3.20E+03
SD13	130	9609	1.27E+08	2.96E+01	9.26E-01	6.71E+05	4.00E+03
SD13	131	9609	1.27E+08	2.96E+01	9.26E-01	6.75E+05	3.20E+03
SD13	132	9609	1.28E+08	2.96E+01	9.25E-01	6.78E+05	4.00E+03

Table A-1 MACCS Plume Segment Characteristics (cont.)

STG	Plume Segment	MELCOR Pathway	PLHEAT (J/s)	PLMFLA (kg/s)	PLMDEN (kg/m3)	PDELAY (s)	PLUDUR (s)*
SD13	133	9609	1.28E+08	2.96E+01	9.25E-01	6.82E+05	3.20E+03
SD13	134	9609	1.28E+08	2.96E+01	9.25E-01	6.85E+05	4.00E+03
SD13	135	9609	1.28E+08	2.96E+01	9.25E-01	6.89E+05	3.20E+03
SD13	136	9609	1.28E+08	2.96E+01	9.25E-01	6.92E+05	4.00E+03
SD13	137	9609	1.28E+08	2.97E+01	9.24E-01	6.96E+05	3.20E+03
SD13	138	9609	1.28E+08	2.97E+01	9.24E-01	7.00E+05	4.00E+03
SD13	139	9609	1.28E+08	2.97E+01	9.24E-01	7.04E+05	3.20E+03
SD13	140	9609	1.28E+08	2.97E+01	9.24E-01	7.07E+05	4.00E+03
SD13	141	9609	1.28E+08	2.97E+01	9.23E-01	7.11E+05	3.20E+03
SD13	142	9609	1.28E+08	2.97E+01	9.23E-01	7.14E+05	4.00E+03
SD13	143	9609	1.28E+08	2.97E+01	9.23E-01	7.18E+05	3.20E+03
SD13	144	9609	1.28E+08	2.98E+01	9.22E-01	7.21E+05	4.00E+03
SD13	145	9609	1.28E+08	2.97E+01	9.22E-01	7.25E+05	3.20E+03
SD13	146	9609	1.28E+08	2.97E+01	9.22E-01	7.28E+05	4.00E+03
SD13	147	9609	1.28E+08	2.97E+01	9.22E-01	7.32E+05	3.20E+03
SD13	148	9609	1.28E+08	2.98E+01	9.22E-01	7.36E+05	4.00E+03
SD13	149	9609	1.29E+08	2.98E+01	9.20E-01	7.40E+05	3.20E+03
SD13	150	9609	1.29E+08	2.98E+01	9.20E-01	7.43E+05	4.00E+03
SD13	151	9609	1.29E+08	2.98E+01	9.20E-01	7.47E+05	3.20E+03
SD13	152	9609	1.29E+08	2.99E+01	9.20E-01	7.50E+05	4.00E+03
SD13	153	9609	1.29E+08	2.98E+01	9.20E-01	7.54E+05	3.20E+03
SD13	154	9609	1.29E+08	2.98E+01	9.20E-01	7.57E+05	4.00E+03
SD13	155	9609	1.29E+08	2.98E+01	9.20E-01	7.61E+05	3.20E+03
SD13	156	9609	1.29E+08	2.99E+01	9.19E-01	7.64E+05	4.00E+03
SD13	157	9609	1.29E+08	3.00E+01	9.17E-01	7.68E+05	3.20E+03
SD13	158	9609	1.29E+08	2.99E+01	9.19E-01	7.72E+05	4.00E+03
SD13	159	9609	1.29E+08	2.99E+01	9.19E-01	7.76E+05	3.20E+03
SD13	160	9609	1.29E+08	2.99E+01	9.18E-01	7.79E+05	4.00E+03
SD13	161	9609	1.29E+08	2.99E+01	9.19E-01	7.83E+05	3.20E+03
SD13	162	9609	1.29E+08	2.99E+01	9.18E-01	7.86E+05	4.00E+03
SD13	163	9609	1.29E+08	2.99E+01	9.19E-01	7.90E+05	3.20E+03
SD13	164	9609	1.29E+08	3.00E+01	9.17E-01	7.93E+05	4.00E+03
SD13	165	9609	1.30E+08	3.00E+01	9.16E-01	7.97E+05	3.20E+03
SD13	166	9609	1.30E+08	3.00E+01	9.16E-01	8.00E+05	2.40E+03

Table A-2 Plume Segment Release Fractions

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD01	1	820	9.42E-05	4.66E-06	5.46E-08	4.23E-06	4.40E-06	1.18E-07	1.17E-06	1.96E-12	1.95E-12
SD01	2	821	7.81E-05	3.87E-06	4.53E-08	3.51E-06	3.65E-06	9.80E-08	9.73E-07	1.62E-12	1.62E-12
SD01	3	824	4.23E-05	2.10E-06	2.46E-08	1.91E-06	1.99E-06	5.33E-08	5.29E-07	8.84E-13	8.83E-13
SD01	4	820	1.64E-04	2.26E-07	8.33E-08	3.01E-07	2.22E-07	1.51E-08	4.40E-08	3.38E-08	4.36E-09
SD01	5	821	1.38E-04	2.06E-07	7.86E-08	2.71E-07	1.99E-07	1.37E-08	4.04E-08	3.22E-08	4.14E-09
SD01	6	824	7.46E-05	1.12E-07	4.29E-08	1.47E-07	1.08E-07	7.48E-09	2.20E-08	1.76E-08	2.26E-09
SD01	7	27	7.84E-07	2.21E-12	1.54E-13	4.44E-12	2.32E-12	8.70E-14	5.55E-13	5.30E-14	6.83E-15
SD01	8	27	8.69E-07	8.12E-13	1.20E-13	3.10E-12	8.13E-13	3.51E-14	1.94E-13	4.81E-14	6.19E-15
SD01	9	27	9.61E-07	4.60E-13	8.32E-14	2.80E-12	4.03E-13	1.90E-14	9.39E-14	3.37E-14	4.34E-15
SD01	10	27	1.21E-06	3.08E-13	6.42E-14	3.09E-12	2.43E-13	1.22E-14	5.50E-14	2.52E-14	3.26E-15
SD01	11	820	1.78E-04	6.15E-08	2.07E-08	1.68E-07	3.15E-08	1.74E-09	3.48E-09	6.52E-09	8.69E-10
SD01	12	821	1.48E-04	5.10E-08	1.72E-08	1.39E-07	2.61E-08	1.45E-09	2.89E-09	5.41E-09	7.21E-10
SD01	13	824	7.99E-05	2.76E-08	9.32E-09	7.55E-08	1.42E-08	7.85E-10	1.56E-09	2.93E-09	3.91E-10
SD01	14	27	1.15E-06	1.59E-13	3.70E-14	2.68E-12	1.16E-13	5.98E-15	2.53E-14	1.37E-14	1.78E-15
SD01	15	27	1.24E-06	1.02E-13	2.54E-14	2.69E-12	7.01E-14	3.56E-15	1.43E-14	8.70E-15	1.14E-15
SD01	16	27	1.32E-06	7.25E-14	1.84E-14	2.73E-12	4.64E-14	2.20E-15	8.47E-15	5.72E-15	7.59E-16
SD01	17	27	1.41E-06	5.50E-14	1.38E-14	2.79E-12	3.48E-14	1.43E-15	5.25E-15	3.91E-15	5.30E-16
SD01	18	27	1.71E-06	5.11E-14	1.20E-14	3.30E-12	3.43E-14	1.08E-15	3.82E-15	3.11E-15	4.35E-16
SD01	19	27	1.58E-06	4.09E-14	8.35E-15	2.99E-12	3.01E-14	6.58E-16	2.26E-15	1.99E-15	2.90E-16
SD01	20	820	1.84E-04	4.05E-08	4.44E-09	4.03E-07	3.66E-08	1.86E-10	3.54E-10	7.73E-10	1.50E-10
SD01	21	821	1.52E-04	3.36E-08	3.68E-09	3.34E-07	3.03E-08	1.54E-10	2.94E-10	6.41E-10	1.24E-10
SD01	22	824	8.26E-05	1.82E-08	1.99E-09	1.81E-07	1.64E-08	8.35E-11	1.59E-10	3.47E-10	6.72E-11
SD01	23	27	1.67E-06	4.20E-14	7.08E-15	3.10E-12	3.34E-14	4.98E-16	1.67E-15	1.56E-15	2.41E-16
SD01	24	27	1.75E-06	4.50E-14	6.25E-15	3.21E-12	3.74E-14	3.95E-16	1.31E-15	1.28E-15	2.10E-16
SD01	25	27	1.83E-06	4.88E-14	5.66E-15	3.31E-12	4.12E-14	3.22E-16	1.07E-15	1.07E-15	1.91E-16
SD01	26	27	2.18E-06	5.73E-14	5.91E-15	3.83E-12	5.06E-14	2.94E-16	9.09E-16	1.04E-15	2.01E-16

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD01	27	27	1.98E-06	5.01E-14	4.77E-15	3.35E-12	4.75E-14	2.02E-16	5.34E-16	7.75E-16	1.65E-16
SD01	28	27	2.06E-06	5.25E-14	4.54E-15	3.37E-12	5.24E-14	1.72E-16	4.42E-16	6.86E-16	1.60E-16
SD01	29	820	1.95E-04	4.02E-08	3.19E-09	2.35E-07	6.29E-08	7.05E-11	2.30E-10	3.34E-10	1.07E-10
SD01	30	821	1.65E-04	3.40E-08	2.96E-09	1.97E-07	5.45E-08	6.75E-11	2.97E-10	2.94E-10	9.26E-11
SD01	31	824	8.94E-05	1.85E-08	1.61E-09	1.07E-07	2.96E-08	3.66E-11	1.62E-10	1.59E-10	5.02E-11
SD01	32	27	2.15E-06	5.57E-14	4.34E-15	3.37E-12	5.92E-14	1.46E-16	3.59E-16	6.11E-16	1.55E-16
SD01	33	27	2.23E-06	5.70E-14	4.19E-15	3.37E-12	6.78E-14	1.24E-16	2.90E-16	5.46E-16	1.51E-16
SD01	34	27	2.64E-06	6.52E-14	4.66E-15	3.85E-12	8.97E-14	1.20E-16	2.72E-16	5.58E-16	1.69E-16
SD01	35	27	2.42E-06	5.67E-14	4.19E-15	3.44E-12	9.11E-14	9.97E-17	2.65E-16	4.61E-16	1.49E-16
SD01	36	27	2.52E-06	4.98E-14	5.32E-15	3.58E-12	9.53E-14	1.22E-16	7.56E-16	4.65E-16	1.48E-16
SD01	37	27	2.54E-06	4.56E-14	5.84E-15	3.62E-12	9.81E-14	1.16E-16	1.15E-15	4.14E-16	1.35E-16
SD01	38	820	1.99E-04	4.66E-08	4.72E-09	1.48E-07	1.35E-07	5.72E-11	1.87E-09	2.16E-10	9.04E-11
SD01	39	821	1.65E-04	3.86E-08	3.91E-09	1.23E-07	1.12E-07	4.74E-11	1.55E-09	1.79E-10	7.49E-11
SD01	40	824	8.94E-05	2.09E-08	2.12E-09	6.66E-08	6.07E-08	2.57E-11	8.39E-10	9.70E-11	4.06E-11
SD01	41	27	2.60E-06	4.69E-14	5.98E-15	3.70E-12	1.08E-13	1.05E-16	1.43E-15	3.70E-16	1.26E-16
SD01	42	27	3.05E-06	5.86E-14	6.79E-15	4.34E-12	1.44E-13	1.06E-16	1.87E-15	3.78E-16	1.38E-16
SD01	43	27	2.74E-06	5.50E-14	5.88E-15	3.88E-12	1.48E-13	8.17E-17	1.77E-15	2.99E-16	1.17E-16
SD01	44	27	2.81E-06	6.02E-14	5.90E-15	3.96E-12	1.72E-13	7.20E-17	2.39E-15	2.76E-16	1.16E-16
SD01	45	27	2.87E-06	6.54E-14	5.98E-15	4.03E-12	2.00E-13	6.46E-17	2.86E-15	2.59E-16	1.16E-16
SD01	46	27	2.93E-06	6.99E-14	6.12E-15	4.08E-12	2.29E-13	5.83E-17	2.99E-15	2.46E-16	1.17E-16
SD01	47	820	2.03E-04	7.25E-08	6.01E-09	1.66E-07	3.20E-07	2.88E-11	3.67E-09	1.54E-10	9.02E-11
SD01	48	821	1.69E-04	6.01E-08	4.99E-09	1.38E-07	2.66E-07	2.39E-11	3.04E-09	1.28E-10	7.48E-11
SD01	49	824	9.14E-05	3.26E-08	2.70E-09	7.47E-08	1.44E-07	1.30E-11	1.65E-09	6.92E-11	4.05E-11
SD01	50	27	3.43E-06	8.55E-14	7.26E-15	4.74E-12	3.00E-13	6.01E-17	3.36E-15	2.69E-16	1.36E-16
SD01	51	27	3.06E-06	8.14E-14	6.88E-15	4.38E-12	3.08E-13	4.77E-17	3.23E-15	2.26E-16	1.21E-16
SD01	52	27	3.13E-06	9.09E-14	7.63E-15	4.77E-12	3.70E-13	4.38E-17	4.24E-15	2.20E-16	1.23E-16
SD01	53	27	3.27E-06	1.03E-13	8.62E-15	5.26E-12	4.54E-13	4.12E-17	5.39E-15	2.20E-16	1.28E-16

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD01	54	27	2.97E-06	1.01E-13	8.35E-15	4.94E-12	4.71E-13	3.43E-17	5.63E-15	1.91E-16	1.16E-16
SD01	55	27	3.78E-06	1.37E-13	1.13E-14	6.44E-12	6.77E-13	3.95E-17	8.14E-15	2.34E-16	1.47E-16
SD01	56	820	2.14E-04	1.09E-07	9.06E-09	2.10E-07	6.16E-07	1.69E-11	7.95E-09	1.29E-10	9.16E-11
SD01	57	821	1.77E-04	9.04E-08	7.51E-09	1.74E-07	5.11E-07	1.40E-11	6.60E-09	1.07E-10	7.60E-11
SD01	58	824	9.62E-05	4.90E-08	4.08E-09	9.46E-08	2.77E-07	7.60E-12	3.58E-09	5.81E-11	4.12E-11
SD01	59	27	3.08E-06	1.18E-13	9.76E-15	5.32E-12	6.10E-13	2.88E-17	7.41E-15	1.82E-16	1.18E-16
SD01	60	27	3.92E-06	1.59E-13	1.31E-14	6.84E-12	8.49E-13	3.34E-17	1.04E-14	2.23E-16	1.49E-16
SD01	61	27	3.19E-06	1.36E-13	1.11E-14	5.59E-12	7.45E-13	2.45E-17	9.31E-15	1.75E-16	1.20E-16
SD01	62	27	4.06E-06	1.79E-13	1.48E-14	7.12E-12	1.01E-12	2.86E-17	1.29E-14	2.14E-16	1.51E-16
SD01	63	27	3.30E-06	1.50E-13	1.25E-14	5.80E-12	8.60E-13	2.13E-17	1.14E-14	1.68E-16	1.22E-16
SD01	64	27	4.19E-06	1.93E-13	1.64E-14	7.38E-12	1.13E-12	2.41E-17	1.53E-14	2.06E-16	1.52E-16
SD01	65	820	2.21E-04	1.20E-07	1.10E-08	2.45E-07	7.38E-07	1.03E-11	1.05E-08	1.13E-10	8.99E-11
SD01	66	821	1.83E-04	9.93E-08	9.10E-09	2.03E-07	6.12E-07	8.55E-12	8.70E-09	9.35E-11	7.46E-11
SD01	67	824	9.92E-05	5.39E-08	4.94E-09	1.10E-07	3.32E-07	4.64E-12	4.72E-09	5.07E-11	4.05E-11
SD01	68	27	3.41E-06	1.58E-13	1.37E-14	6.03E-12	9.38E-13	1.82E-17	1.29E-14	1.62E-16	1.22E-16
SD01	69	27	4.32E-06	1.99E-13	1.76E-14	7.65E-12	1.20E-12	2.08E-17	1.67E-14	1.99E-16	1.53E-16
SD01	70	27	3.51E-06	1.61E-13	1.44E-14	6.21E-12	9.83E-13	1.52E-17	1.37E-14	1.56E-16	1.22E-16
SD01	71	27	4.45E-06	2.02E-13	1.85E-14	7.87E-12	1.25E-12	1.80E-17	1.76E-14	1.92E-16	1.53E-16
SD01	72	27	3.61E-06	1.62E-13	1.51E-14	6.36E-12	1.01E-12	1.32E-17	1.44E-14	1.51E-16	1.22E-16
SD01	73	27	4.57E-06	2.03E-13	1.93E-14	8.02E-12	1.25E-12	1.52E-17	1.84E-14	1.86E-16	1.52E-16
SD01	74	820	2.27E-04	1.15E-07	1.20E-08	2.29E-07	6.84E-07	6.55E-12	1.16E-08	1.01E-10	8.72E-11
SD01	75	821	1.88E-04	9.57E-08	9.98E-09	1.90E-07	5.67E-07	5.45E-12	9.59E-09	8.41E-11	7.23E-11
SD01	76	824	1.02E-04	5.19E-08	5.41E-09	1.03E-07	3.08E-07	2.96E-12	5.20E-09	4.56E-11	3.92E-11
SD01	77	27	3.71E-06	1.62E-13	1.57E-14	6.48E-12	9.92E-13	1.15E-17	1.50E-14	1.47E-16	1.22E-16
SD01	78	27	4.70E-06	2.02E-13	2.01E-14	8.16E-12	1.23E-12	1.34E-17	1.92E-14	1.81E-16	1.52E-16
SD01	79	27	3.81E-06	1.61E-13	1.63E-14	6.57E-12	9.66E-13	1.02E-17	1.57E-14	1.43E-16	1.21E-16
SD01	80	27	4.82E-06	2.00E-13	2.08E-14	8.28E-12	1.19E-12	1.13E-17	2.00E-14	1.77E-16	1.51E-16

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD01	81	27	3.90E-06	1.59E-13	1.69E-14	6.66E-12	9.35E-13	8.89E-18	1.63E-14	1.40E-16	1.21E-16
SD01	82	27	4.94E-06	1.97E-13	2.14E-14	8.39E-12	1.15E-12	9.97E-18	2.07E-14	1.72E-16	1.50E-16
SD01	83	820	2.33E-04	1.07E-07	1.28E-08	1.96E-07	5.75E-07	4.33E-12	1.22E-08	9.28E-11	8.37E-11
SD01	84	821	1.94E-04	8.86E-08	1.06E-08	1.62E-07	4.77E-07	3.60E-12	1.01E-08	7.69E-11	6.94E-11
SD01	85	824	1.05E-04	4.81E-08	5.77E-09	8.80E-08	2.59E-07	1.95E-12	5.51E-09	4.18E-11	3.76E-11
SD01	86	27	4.00E-06	1.56E-13	1.74E-14	6.75E-12	9.01E-13	7.81E-18	1.68E-14	1.36E-16	1.20E-16
SD01	87	27	5.06E-06	1.94E-13	2.20E-14	8.51E-12	1.10E-12	9.11E-18	2.12E-14	1.69E-16	1.49E-16
SD01	88	27	4.09E-06	1.54E-13	1.79E-14	6.85E-12	8.49E-13	6.51E-18	1.71E-14	1.33E-16	1.19E-16
SD01	89	27	5.18E-06	1.90E-13	2.27E-14	8.65E-12	1.03E-12	7.81E-18	2.16E-14	1.65E-16	1.49E-16
SD01	90	27	4.18E-06	1.50E-13	1.83E-14	6.96E-12	7.92E-13	6.07E-18	1.74E-14	1.31E-16	1.18E-16
SD01	91	27	5.28E-06	1.85E-13	2.32E-14	8.76E-12	9.56E-13	6.94E-18	2.18E-14	1.62E-16	1.47E-16
SD01	92	820	2.39E-04	9.56E-08	1.33E-08	1.69E-07	4.59E-07	2.96E-12	1.20E-08	8.57E-11	7.98E-11
SD01	93	821	1.98E-04	7.93E-08	1.10E-08	1.40E-07	3.80E-07	2.44E-12	9.95E-09	7.11E-11	6.62E-11
SD01	94	824	1.08E-04	4.30E-08	5.96E-09	7.61E-08	2.06E-07	1.32E-12	5.40E-09	3.86E-11	3.59E-11
SD01	95	27	4.27E-06	1.46E-13	1.87E-14	7.05E-12	7.38E-13	5.20E-18	1.75E-14	1.28E-16	1.17E-16
SD01	96	27	5.40E-06	1.80E-13	2.36E-14	8.90E-12	8.94E-13	6.07E-18	2.19E-14	1.59E-16	1.46E-16
SD01	97	27	4.35E-06	1.42E-13	1.90E-14	7.16E-12	6.92E-13	4.77E-18	1.75E-14	1.26E-16	1.16E-16
SD01	98	27	5.50E-06	1.74E-13	2.39E-14	9.01E-12	8.39E-13	5.42E-18	2.17E-14	1.55E-16	1.44E-16
SD01	99	27	4.45E-06	1.37E-13	1.93E-14	7.27E-12	6.53E-13	4.34E-18	1.73E-14	1.23E-16	1.15E-16
SD01	100	27	5.60E-06	1.67E-13	2.41E-14	9.13E-12	7.93E-13	4.55E-18	2.14E-14	1.53E-16	1.43E-16
SD01	101	820	2.44E-04	8.25E-08	1.34E-08	1.42E-07	3.86E-07	2.05E-12	1.10E-08	7.97E-11	7.60E-11
SD01	102	821	2.03E-04	6.84E-08	1.11E-08	1.18E-07	3.20E-07	1.70E-12	9.10E-09	6.61E-11	6.30E-11
SD01	103	824	1.10E-04	3.71E-08	6.05E-09	6.38E-08	1.74E-07	9.24E-13	4.94E-09	3.59E-11	3.42E-11
SD01	104	27	4.53E-06	1.31E-13	1.94E-14	7.37E-12	6.19E-13	3.69E-18	1.70E-14	1.21E-16	1.14E-16
SD01	105	27	5.71E-06	1.61E-13	2.43E-14	9.25E-12	7.53E-13	4.34E-18	2.09E-14	1.50E-16	1.42E-16
SD01	106	27	4.61E-06	1.26E-13	1.96E-14	7.46E-12	5.89E-13	3.47E-18	1.65E-14	1.19E-16	1.13E-16
SD01	107	27	5.80E-06	1.53E-13	2.47E-14	9.36E-12	7.18E-13	3.69E-18	2.03E-14	1.47E-16	1.40E-16

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD01	108	27	4.69E-06	1.20E-13	2.00E-14	7.55E-12	5.63E-13	3.04E-18	1.60E-14	1.17E-16	1.12E-16
SD01	109	27	5.91E-06	1.46E-13	2.51E-14	9.48E-12	6.88E-13	3.25E-18	1.96E-14	1.45E-16	1.39E-16
SD01	110	820	2.49E-04	6.94E-08	1.40E-08	1.18E-07	3.37E-07	1.45E-12	9.54E-09	7.48E-11	7.25E-11
SD01	111	821	2.07E-04	5.75E-08	1.16E-08	9.83E-08	2.79E-07	1.22E-12	7.91E-09	6.20E-11	6.01E-11
SD01	112	824	1.12E-04	3.12E-08	6.28E-09	5.33E-08	1.52E-07	6.61E-13	4.29E-09	3.37E-11	3.26E-11
SD01	113	27	4.76E-06	1.14E-13	2.03E-14	7.63E-12	5.40E-13	2.82E-18	1.54E-14	1.15E-16	1.10E-16
SD01	114	27	6.01E-06	1.39E-13	2.56E-14	9.60E-12	6.62E-13	3.04E-18	1.89E-14	1.43E-16	1.37E-16
SD01	115	27	4.84E-06	1.08E-13	2.07E-14	7.72E-12	5.19E-13	2.39E-18	1.47E-14	1.13E-16	1.09E-16
SD01	116	27	6.09E-06	1.31E-13	2.60E-14	9.70E-12	6.36E-13	2.82E-18	1.80E-14	1.40E-16	1.36E-16
SD01	117	27	4.92E-06	1.02E-13	2.10E-14	7.81E-12	4.99E-13	2.17E-18	1.41E-14	1.12E-16	1.08E-16
SD01	118	27	6.19E-06	1.24E-13	2.64E-14	9.81E-12	6.11E-13	2.60E-18	1.72E-14	1.38E-16	1.35E-16
SD01	119	820	2.54E-04	5.75E-08	1.44E-08	1.01E-07	2.99E-07	1.08E-12	8.06E-09	7.13E-11	7.00E-11
SD01	120	821	2.10E-04	4.77E-08	1.19E-08	8.38E-08	2.48E-07	8.81E-13	6.68E-09	5.91E-11	5.81E-11
SD01	121	824	1.14E-04	2.59E-08	6.48E-09	4.55E-08	1.35E-07	4.76E-13	3.63E-09	3.21E-11	3.15E-11
SD01	122	27	4.98E-06	9.64E-14	2.13E-14	7.87E-12	4.78E-13	1.95E-18	1.34E-14	1.10E-16	1.07E-16
SD01	123	27	6.28E-06	1.17E-13	2.68E-14	9.92E-12	5.89E-13	2.39E-18	1.63E-14	1.37E-16	1.34E-16
SD01	124	27	5.06E-06	9.12E-14	2.16E-14	7.97E-12	4.64E-13	1.52E-18	1.27E-14	1.09E-16	1.07E-16
SD01	125	27	6.37E-06	1.11E-13	2.71E-14	1.00E-11	5.71E-13	1.95E-18	1.54E-14	1.35E-16	1.33E-16
SD01	126	27	5.13E-06	8.59E-14	2.19E-14	8.05E-12	4.52E-13	1.73E-18	1.20E-14	1.08E-16	1.06E-16
SD01	127	27	6.45E-06	1.04E-13	2.78E-14	1.01E-11	5.60E-13	1.73E-18	1.47E-14	1.35E-16	1.33E-16
SD01	128	820	2.57E-04	4.73E-08	1.66E-08	8.73E-08	3.01E-07	7.82E-13	8.73E-09	7.11E-11	7.07E-11
SD01	129	821	2.13E-04	3.92E-08	1.38E-08	7.24E-08	2.50E-07	6.54E-13	7.24E-09	5.90E-11	5.86E-11
SD01	130	824	1.16E-04	2.13E-08	7.48E-09	3.93E-08	1.36E-07	3.55E-13	3.93E-09	3.20E-11	3.18E-11
SD01	131	27	5.18E-06	8.07E-14	2.27E-14	8.11E-12	4.46E-13	1.52E-18	1.15E-14	1.08E-16	1.06E-16
SD01	132	27	6.54E-06	9.81E-14	2.93E-14	1.02E-11	5.60E-13	1.52E-18	1.43E-14	1.35E-16	1.34E-16
SD01	133	27	5.26E-06	7.61E-14	2.42E-14	8.20E-12	4.51E-13	1.30E-18	1.17E-14	1.08E-16	1.08E-16
SD01	134	27	6.62E-06	9.21E-14	3.14E-14	1.03E-11	5.72E-13	1.73E-18	1.56E-14	1.36E-16	1.35E-16

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD01	135	27	5.32E-06	7.15E-14	2.62E-14	8.26E-12	4.70E-13	1.08E-18	1.43E-14	1.10E-16	1.09E-16
SD01	136	27	6.69E-06	8.64E-14	3.42E-14	1.04E-11	6.15E-13	1.73E-18	2.39E-13	1.38E-16	1.37E-16
SD01	137	820	2.60E-04	3.43E-08	3.01E-08	5.52E-08	2.79E-07	5.54E-13	4.23E-05	4.26E-11	4.27E-11
SD01	138	821	2.16E-04	2.85E-08	2.49E-08	4.58E-08	2.32E-07	4.55E-13	3.51E-05	3.53E-11	3.54E-11
SD01	139	824	1.17E-04	1.55E-08	1.35E-08	2.49E-08	1.26E-07	2.49E-13	1.90E-05	1.92E-11	1.92E-11
SD01	140	27	5.39E-06	3.97E-14	1.82E-14	8.29E-12	3.19E-13	4.34E-19	2.20E-11	6.57E-17	6.56E-17
SD01	141	27	6.77E-06	2.63E-14	2.79E-14	1.04E-11	2.60E-13	4.34E-19	4.53E-11	4.34E-17	4.35E-17
SD01	142	27	5.45E-06	1.92E-14	2.50E-14	8.32E-12	1.92E-13	4.34E-19	3.46E-11	2.71E-17	2.71E-17
SD01	143	27	6.85E-06	2.86E-14	3.02E-14	1.04E-11	2.33E-13	6.51E-19	3.75E-11	3.05E-17	3.06E-17
SD01	144	27	5.51E-06	2.97E-14	2.31E-14	8.38E-12	1.81E-13	2.17E-19	2.56E-11	2.38E-17	2.39E-17
SD01	145	27	6.92E-06	4.92E-14	2.81E-14	1.05E-11	2.20E-13	6.51E-19	2.73E-11	3.05E-17	3.06E-17
SD01	146	820	2.63E-04	9.75E-08	2.35E-08	3.84E-08	1.55E-07	7.25E-13	1.37E-05	3.03E-11	3.06E-11
SD01	147	821	2.18E-04	8.09E-08	1.95E-08	3.18E-08	1.28E-07	6.04E-13	1.14E-05	2.51E-11	2.53E-11
SD01	148	824	1.19E-04	4.39E-08	1.06E-08	1.73E-08	6.96E-08	3.34E-13	6.18E-06	1.36E-11	1.38E-11
SD01	149	27	5.56E-06	5.13E-14	2.25E-14	8.44E-12	1.70E-13	4.34E-19	1.88E-11	2.57E-17	2.58E-17
SD01	150	27	6.99E-06	8.21E-14	2.87E-14	1.06E-11	2.05E-13	8.67E-19	2.05E-11	3.45E-17	3.47E-17
SD01	151	27	5.62E-06	8.25E-14	2.35E-14	8.50E-12	1.58E-13	8.67E-19	1.46E-11	2.95E-17	2.98E-17
SD01	152	27	7.06E-06	1.28E-13	2.97E-14	1.07E-11	1.90E-13	8.67E-19	1.63E-11	3.89E-17	3.93E-17
SD01	153	27	5.67E-06	1.24E-13	2.39E-14	8.57E-12	1.45E-13	6.51E-19	1.18E-11	3.23E-17	3.27E-17
SD01	154	27	7.13E-06	1.84E-13	3.00E-14	1.08E-11	1.74E-13	8.67E-19	1.35E-11	4.19E-17	4.25E-17
SD01	155	820	2.66E-04	2.02E-07	2.40E-08	4.19E-08	1.02E-07	7.39E-13	6.80E-06	3.60E-11	3.66E-11
SD01	156	821	2.21E-04	1.68E-07	1.99E-08	3.47E-08	8.46E-08	6.18E-13	5.64E-06	2.98E-11	3.03E-11
SD01	157	824	1.20E-04	9.10E-08	1.08E-08	1.89E-08	4.59E-08	3.34E-13	3.06E-06	1.62E-11	1.65E-11
SD01	158	27	5.73E-06	1.71E-13	2.43E-14	8.64E-12	1.33E-13	6.51E-19	9.91E-12	3.50E-17	3.55E-17
SD01	159	27	7.19E-06	2.43E-13	3.16E-14	1.08E-11	1.60E-13	1.08E-18	1.15E-11	4.63E-17	4.71E-17
SD01	160	27	5.78E-06	2.18E-13	2.65E-14	8.70E-12	1.24E-13	8.67E-19	8.54E-12	3.95E-17	4.01E-17
SD01	161	27	7.26E-06	3.01E-13	3.55E-14	1.09E-11	1.50E-13	1.08E-18	1.00E-11	5.32E-17	5.41E-17

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD01	162	27	5.83E-06	2.64E-13	3.08E-14	8.76E-12	1.17E-13	1.08E-18	7.58E-12	4.63E-17	4.70E-17
SD01	163	27	7.32E-06	3.59E-13	4.19E-14	1.10E-11	1.43E-13	1.30E-18	9.02E-12	6.30E-17	6.40E-17
SD01	164	820	2.68E-04	2.74E-07	3.36E-08	4.56E-08	7.55E-08	1.19E-12	4.37E-06	4.99E-11	5.07E-11
SD01	165	821	2.22E-04	2.28E-07	2.79E-08	3.78E-08	6.26E-08	9.88E-13	3.63E-06	4.14E-11	4.20E-11
SD01	166	824	1.21E-04	1.24E-07	1.51E-08	2.05E-08	3.40E-08	5.33E-13	1.97E-06	2.25E-11	2.28E-11
SD01	167	27	5.88E-06	3.11E-13	3.65E-14	8.81E-12	1.12E-13	1.08E-18	6.89E-12	5.48E-17	5.56E-17
SD01	168	27	7.38E-06	4.17E-13	4.95E-14	1.11E-11	1.37E-13	1.95E-18	8.26E-12	7.41E-17	7.52E-17
SD01	169	27	5.93E-06	3.55E-13	4.28E-14	8.87E-12	1.08E-13	1.30E-18	6.35E-12	6.38E-17	6.48E-17
SD01	170	27	7.44E-06	4.70E-13	5.74E-14	1.11E-11	1.31E-13	2.39E-18	7.63E-12	8.54E-17	8.66E-17
SD01	171	27	5.97E-06	3.95E-13	4.91E-14	8.92E-12	1.02E-13	1.52E-18	5.87E-12	7.27E-17	7.38E-17
SD01	172	27	7.50E-06	5.16E-13	6.53E-14	1.12E-11	1.24E-13	2.39E-18	7.06E-12	9.63E-17	9.76E-17
SD01	173	820	2.70E-04	3.13E-07	4.32E-08	4.77E-08	5.76E-08	1.59E-12	3.15E-06	6.25E-11	6.34E-11
SD01	174	821	2.24E-04	2.60E-07	3.59E-08	3.96E-08	4.77E-08	1.31E-12	2.61E-06	5.18E-11	5.25E-11
SD01	175	824	1.22E-04	1.41E-07	1.95E-08	2.15E-08	2.59E-08	7.11E-13	1.42E-06	2.82E-11	2.85E-11
SD01	176	27	6.02E-06	4.29E-13	5.52E-14	8.97E-12	9.65E-14	1.95E-18	5.42E-12	8.11E-17	8.22E-17
SD01	177	27	7.55E-06	5.53E-13	7.27E-14	1.12E-11	1.17E-13	2.82E-18	6.51E-12	1.06E-16	1.08E-16
SD01	178	27	6.06E-06	4.54E-13	6.09E-14	9.02E-12	9.03E-14	2.17E-18	4.99E-12	8.86E-17	8.98E-17
SD01	179	27	7.60E-06	5.79E-13	7.94E-14	1.13E-11	1.09E-13	2.82E-18	5.98E-12	1.15E-16	1.17E-16
SD01	180	27	6.10E-06	4.71E-13	6.60E-14	9.06E-12	8.39E-14	2.60E-18	4.58E-12	9.51E-17	9.65E-17
SD01	181	27	7.66E-06	5.95E-13	8.54E-14	1.14E-11	1.01E-13	2.82E-18	5.48E-12	1.23E-16	1.24E-16
SD01	182	820	2.72E-04	3.18E-07	5.05E-08	4.84E-08	4.44E-08	1.82E-12	2.37E-06	7.12E-11	7.21E-11
SD01	183	821	2.26E-04	2.64E-07	4.19E-08	4.01E-08	3.68E-08	1.51E-12	1.96E-06	5.90E-11	5.98E-11
SD01	184	824	1.23E-04	1.43E-07	2.28E-08	2.18E-08	2.00E-08	8.17E-13	1.07E-06	3.21E-11	3.25E-11
SD01	185	27	6.15E-06	4.80E-13	7.05E-14	9.11E-12	7.75E-14	2.82E-18	4.19E-12	1.01E-16	1.02E-16
SD01	186	27	7.71E-06	6.02E-13	9.06E-14	1.14E-11	9.30E-14	3.04E-18	5.00E-12	1.29E-16	1.31E-16
SD01	187	27	6.19E-06	4.82E-13	7.43E-14	9.15E-12	7.13E-14	2.82E-18	3.82E-12	1.05E-16	1.07E-16
SD01	188	27	7.76E-06	6.01E-13	9.48E-14	1.15E-11	8.54E-14	3.47E-18	4.56E-12	1.34E-16	1.35E-16

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD01	189	27	6.22E-06	4.78E-13	7.67E-14	9.19E-12	6.53E-14	2.60E-18	3.48E-12	1.08E-16	1.09E-16
SD01	190	27	7.80E-06	5.92E-13	9.71E-14	1.15E-11	7.80E-14	3.69E-18	4.14E-12	1.36E-16	1.38E-16
SD01	191	820	2.74E-04	3.00E-07	5.43E-08	4.79E-08	3.41E-08	1.86E-12	1.79E-06	7.48E-11	7.58E-11
SD01	192	821	2.27E-04	2.49E-07	4.50E-08	3.97E-08	2.83E-08	1.56E-12	1.49E-06	6.21E-11	6.29E-11
SD01	193	824	1.23E-04	1.35E-07	2.44E-08	2.16E-08	1.54E-08	8.46E-13	8.08E-07	3.37E-11	3.42E-11
SD01	194	27	6.26E-06	4.69E-13	7.86E-14	9.23E-12	5.96E-14	2.82E-18	3.15E-12	1.10E-16	1.11E-16
SD01	195	27	7.85E-06	5.78E-13	9.92E-14	1.16E-11	7.11E-14	3.47E-18	3.75E-12	1.38E-16	1.40E-16
SD01	196	27	6.30E-06	4.56E-13	8.01E-14	9.26E-12	5.43E-14	2.82E-18	2.86E-12	1.11E-16	1.12E-16
SD01	197	27	7.90E-06	5.60E-13	1.01E-13	1.16E-11	6.47E-14	3.47E-18	3.40E-12	1.39E-16	1.41E-16
SD01	198	27	6.34E-06	4.40E-13	8.07E-14	9.30E-12	4.94E-14	2.60E-18	2.59E-12	1.11E-16	1.13E-16
SD01	199	27	7.94E-06	5.39E-13	1.01E-13	1.16E-11	5.88E-14	3.47E-18	3.08E-12	1.39E-16	1.41E-16
SD01	200	820	2.75E-04	2.66E-07	5.56E-08	4.68E-08	2.60E-08	1.80E-12	1.36E-06	7.51E-11	7.61E-11
SD01	201	821	2.28E-04	2.21E-07	4.61E-08	3.88E-08	2.16E-08	1.49E-12	1.12E-06	6.23E-11	6.31E-11
SD01	202	824	1.24E-04	1.20E-07	2.50E-08	2.11E-08	1.17E-08	8.10E-13	6.11E-07	3.38E-11	3.43E-11
SD01	203	27	6.37E-06	4.23E-13	8.09E-14	9.33E-12	4.48E-14	2.82E-18	2.35E-12	1.11E-16	1.12E-16
SD01	204	27	7.98E-06	5.17E-13	1.01E-13	1.17E-11	5.34E-14	3.25E-18	2.79E-12	1.38E-16	1.40E-16
SD01	205	27	6.40E-06	4.04E-13	8.09E-14	9.37E-12	4.07E-14	2.60E-18	2.13E-12	1.10E-16	1.12E-16
SD01	206	27	8.03E-06	4.92E-13	1.02E-13	1.17E-11	4.86E-14	3.25E-18	2.53E-12	1.38E-16	1.39E-16
SD01	207	27	6.44E-06	3.84E-13	8.18E-14	9.39E-12	3.71E-14	2.60E-18	1.93E-12	1.10E-16	1.12E-16
SD01	208	27	8.07E-06	4.69E-13	1.03E-13	1.18E-11	4.43E-14	3.69E-18	2.30E-12	1.38E-16	1.40E-16
SD01	209	820	2.77E-04	2.28E-07	5.69E-08	4.56E-08	1.98E-08	1.76E-12	1.03E-06	7.47E-11	7.58E-11
SD01	210	821	2.30E-04	1.89E-07	4.72E-08	3.78E-08	1.64E-08	1.46E-12	8.51E-07	6.20E-11	6.29E-11
SD01	211	824	1.25E-04	1.03E-07	2.56E-08	2.05E-08	8.92E-09	7.96E-13	4.62E-07	3.37E-11	3.41E-11
SD01	212	27	6.47E-06	3.66E-13	8.30E-14	9.42E-12	3.39E-14	2.39E-18	1.76E-12	1.11E-16	1.12E-16
SD01	213	27	8.11E-06	4.46E-13	1.04E-13	1.18E-11	4.05E-14	3.25E-18	2.10E-12	1.38E-16	1.40E-16
SD01	214	27	6.50E-06	3.48E-13	8.32E-14	9.45E-12	3.10E-14	2.82E-18	1.61E-12	1.10E-16	1.12E-16
SD01	215	27	8.15E-06	4.23E-13	1.04E-13	1.18E-11	3.70E-14	3.04E-18	1.92E-12	1.37E-16	1.39E-16

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD01	216	27	6.53E-06	3.29E-13	8.38E-14	9.48E-12	2.83E-14	2.60E-18	1.47E-12	1.10E-16	1.11E-16
SD01	217	27	8.18E-06	4.01E-13	1.05E-13	1.19E-11	3.38E-14	3.25E-18	1.75E-12	1.36E-16	1.38E-16
SD01	218	820	1.44E-04	1.04E-07	2.95E-08	2.32E-08	8.33E-09	8.67E-13	4.30E-07	3.80E-11	3.85E-11
SD01	219	821	1.19E-04	8.60E-08	2.45E-08	1.92E-08	6.91E-09	7.18E-13	3.57E-07	3.15E-11	3.20E-11
SD01	220	824	6.49E-05	4.67E-08	1.33E-08	1.04E-08	3.75E-09	3.91E-13	1.94E-07	1.71E-11	1.74E-11
SD01	221	27	6.56E-06	3.12E-13	8.36E-14	9.50E-12	2.59E-14	2.39E-18	1.34E-12	1.09E-16	1.10E-16
SD01	222	27	1.90E-05	7.99E-13	2.22E-13	2.54E-11	6.51E-14	6.72E-18	3.36E-12	2.87E-16	2.91E-16
SD01-2	1	820	9.42E-05	4.66E-06	5.46E-08	4.23E-06	4.40E-06	1.18E-07	1.17E-06	1.96E-12	1.95E-12
SD01-2	2	821	7.81E-05	3.87E-06	4.53E-08	3.51E-06	3.65E-06	9.80E-08	9.73E-07	1.62E-12	1.62E-12
SD01-2	3	824	4.23E-05	2.10E-06	2.46E-08	1.91E-06	1.99E-06	5.33E-08	5.29E-07	8.84E-13	8.83E-13
SD01-2	4	820	1.64E-04	2.27E-07	8.57E-08	2.96E-07	2.16E-07	1.50E-08	4.33E-08	3.62E-08	4.64E-09
SD01-2	5	821	1.37E-04	2.03E-07	7.94E-08	2.64E-07	1.91E-07	1.34E-08	3.90E-08	3.36E-08	4.30E-09
SD01-2	6	824	7.45E-05	1.11E-07	4.31E-08	1.43E-07	1.04E-07	7.30E-09	2.12E-08	1.83E-08	2.34E-09
SD01-2	7	820	1.82E-04	6.27E-08	2.03E-08	1.68E-07	3.03E-08	1.59E-09	3.10E-09	6.43E-09	8.54E-10
SD01-2	8	821	1.50E-04	5.20E-08	1.69E-08	1.39E-07	2.51E-08	1.32E-09	2.57E-09	5.34E-09	7.09E-10
SD01-2	9	824	8.16E-05	2.82E-08	9.14E-09	7.54E-08	1.36E-08	7.16E-10	1.39E-09	2.89E-09	3.84E-10
SD01-2	10	820	1.82E-04	4.84E-08	5.68E-09	4.72E-07	1.13E-07	2.34E-10	1.59E-09	8.29E-10	1.55E-10
SD01-2	11	821	1.51E-04	4.02E-08	4.71E-09	3.91E-07	9.37E-08	1.94E-10	1.32E-09	6.87E-10	1.29E-10
SD01-2	12	824	8.20E-05	2.18E-08	2.55E-09	2.12E-07	5.08E-08	1.05E-10	7.16E-10	3.73E-10	6.97E-11
SD01-2	13	844	1.10E-02	2.48E-06	2.26E-07	2.62E-05	6.89E-06	1.07E-08	7.46E-08	3.43E-08	6.70E-09
SD01-2	14	844	2.66E-02	7.33E-06	6.62E-07	7.59E-05	2.75E-05	2.62E-08	2.78E-07	8.07E-08	1.65E-08
SD01-2	15	844	2.72E-02	6.88E-06	7.23E-07	6.54E-05	2.34E-05	2.32E-08	3.21E-07	6.83E-08	1.53E-08
SD01-2	16	844	2.50E-02	6.17E-06	8.30E-07	5.16E-05	2.04E-05	1.91E-08	3.23E-07	5.54E-08	1.36E-08
SD01-2	17	820	1.63E-04	5.01E-08	1.27E-08	2.97E-07	1.60E-07	1.07E-10	2.69E-09	3.28E-10	1.04E-10
SD01-2	18	821	1.35E-04	4.16E-08	1.05E-08	2.46E-07	1.33E-07	8.86E-11	2.23E-09	2.72E-10	8.61E-11
SD01-2	19	844	2.34E-02	5.83E-06	1.00E-06	4.16E-05	1.83E-05	1.57E-08	3.11E-07	4.57E-08	1.23E-08
SD01-2	20	844	2.22E-02	5.78E-06	1.28E-06	3.46E-05	1.69E-05	1.30E-08	3.00E-07	3.84E-08	1.13E-08

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD01-2	21	844	2.17E-02	5.49E-06	1.68E-06	3.06E-05	1.66E-05	1.12E-08	2.99E-07	3.41E-08	1.09E-08
SD01-2	22	844	1.69E-02	3.49E-06	1.10E-06	1.94E-05	1.12E-05	6.64E-09	1.94E-07	2.10E-08	7.27E-09
SD01-2	23	844	1.20E-02	2.12E-06	6.18E-07	1.17E-05	7.26E-06	3.65E-09	1.15E-07	1.21E-08	4.59E-09
SD01-2	24	844	1.14E-02	1.95E-06	5.25E-07	1.06E-05	7.14E-06	2.98E-09	1.02E-07	1.04E-08	4.26E-09
SD01-2	25	820	1.47E-04	5.93E-08	9.26E-09	2.20E-07	1.96E-07	4.48E-11	2.11E-09	1.83E-10	9.00E-11
SD01-2	26	821	1.24E-04	5.05E-08	7.76E-09	1.84E-07	1.65E-07	3.74E-11	1.78E-09	1.53E-10	7.56E-11
SD01-2	27	844	1.22E-02	2.28E-06	5.53E-07	1.20E-05	8.75E-06	3.00E-09	1.12E-07	1.10E-08	4.84E-09
SD01-2	28	844	1.24E-02	2.60E-06	5.33E-07	1.27E-05	9.89E-06	2.73E-09	1.14E-07	1.06E-08	4.98E-09
SD01-2	29	844	1.42E-02	3.84E-06	5.86E-07	1.46E-05	1.28E-05	2.79E-09	1.32E-07	1.16E-08	5.80E-09
SD01-2	30	844	1.25E-02	4.09E-06	5.04E-07	1.45E-05	1.29E-05	2.20E-09	1.21E-07	9.80E-09	5.21E-09
SD01-2	31	844	8.86E-02	3.41E-05	4.14E-06	9.50E-05	1.09E-04	1.73E-08	1.21E-06	8.22E-08	4.58E-08
SD01-2	32	820	1.28E-04	4.37E-07	7.06E-09	6.62E-07	3.70E-07	1.62E-11	2.68E-09	1.10E-10	7.53E-11
SD01-2	33	821	1.06E-04	3.62E-07	5.85E-09	5.48E-07	3.06E-07	1.34E-11	2.22E-09	9.10E-11	6.24E-11
SD01-2	34	844	2.23E-03	0.00E+00	0.00E+00	2.30E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SD01-2	35	844	6.75E-03	0.00E+00	0.00E+00	6.95E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SD01-2	36	844	7.90E-03	2.35E-07	2.83E-09	1.16E-06	1.70E-07	5.09E-12	1.18E-09	4.02E-11	2.93E-11
SD01-2	37	844	9.43E-03	3.11E-05	3.14E-07	4.73E-05	1.97E-05	5.08E-10	1.38E-07	4.27E-09	3.18E-09
SD01-2	38	844	1.13E-02	6.70E-05	5.68E-07	1.02E-04	3.71E-05	8.13E-10	2.63E-07	7.33E-09	5.58E-09
SD01-2	39	820	1.19E-04	1.79E-06	9.40E-09	2.76E-06	7.01E-07	8.67E-12	5.36E-09	1.01E-10	8.19E-11
SD01-2	40	821	9.87E-05	1.48E-06	7.79E-09	2.29E-06	5.81E-07	7.18E-12	4.44E-09	8.35E-11	6.79E-11
SD01-2	41	844	1.46E-02	1.13E-04	7.93E-07	1.73E-04	5.43E-05	9.76E-10	3.94E-07	9.62E-09	7.50E-09
SD01-2	42	844	1.48E-02	1.46E-04	8.67E-07	2.25E-04	6.23E-05	9.04E-10	4.64E-07	9.82E-09	7.85E-09
SD01-2	43	844	1.19E-02	1.42E-04	7.45E-07	2.19E-04	5.56E-05	6.71E-10	4.23E-07	7.95E-09	6.49E-09
SD01-2	44	844	1.48E-02	2.09E-04	9.94E-07	3.25E-04	7.68E-05	7.75E-10	5.97E-07	1.00E-08	8.34E-09
SD01-2	45	844	1.18E-02	1.93E-04	8.45E-07	3.00E-04	6.73E-05	5.70E-10	5.35E-07	8.06E-09	6.82E-09
SD01-2	46	844	1.46E-02	2.71E-04	1.12E-06	4.23E-04	8.91E-05	6.54E-10	7.41E-07	1.01E-08	8.67E-09
SD01-2	47	820	1.05E-04	3.16E-06	1.18E-08	4.92E-06	8.01E-07	4.66E-12	8.86E-09	9.18E-11	8.15E-11

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD01-2	48	821	8.68E-05	2.62E-06	9.75E-09	4.08E-06	6.64E-07	3.86E-12	7.34E-09	7.60E-11	6.76E-11
SD01-2	49	824	4.71E-05	1.42E-06	5.28E-09	2.21E-06	3.60E-07	2.10E-12	3.98E-09	4.12E-11	3.66E-11
SD01-2	50	844	1.16E-02	2.40E-04	9.40E-07	3.74E-04	7.00E-05	4.80E-10	6.52E-07	8.08E-09	7.03E-09
SD01-2	51	844	1.15E-02	2.59E-04	9.83E-07	4.04E-04	7.00E-05	4.44E-10	7.09E-07	8.08E-09	7.11E-09
SD01-2	52	844	1.42E-02	3.49E-04	1.29E-06	5.44E-04	8.79E-05	5.08E-10	9.70E-07	1.01E-08	8.98E-09
SD01-2	53	844	1.12E-02	2.97E-04	1.08E-06	4.63E-04	7.07E-05	3.72E-10	8.42E-07	8.06E-09	7.24E-09
SD01-2	54	844	1.38E-02	3.92E-04	1.41E-06	6.10E-04	8.83E-05	4.26E-10	1.13E-06	1.01E-08	9.13E-09
SD01-2	55	844	1.09E-02	3.28E-04	1.18E-06	5.10E-04	7.02E-05	3.12E-10	9.73E-07	8.03E-09	7.35E-09
SD01-2	56	820	9.10E-05	3.26E-06	1.40E-08	5.82E-06	6.83E-07	2.54E-12	1.22E-08	8.41E-11	7.87E-11
SD01-2	57	821	7.54E-05	2.70E-06	1.16E-08	4.82E-06	5.66E-07	2.12E-12	1.01E-08	6.97E-11	6.52E-11
SD01-2	58	824	4.09E-05	1.46E-06	6.29E-09	2.61E-06	3.07E-07	1.14E-12	5.49E-09	3.78E-11	3.53E-11
SD01-2	59	844	1.34E-02	4.25E-04	1.53E-06	6.59E-04	8.69E-05	3.57E-10	1.29E-06	1.00E-08	9.23E-09
SD01-2	60	844	1.05E-02	3.32E-04	1.27E-06	5.42E-04	6.80E-05	2.61E-10	1.10E-06	7.98E-09	7.41E-09
SD01-2	61	844	1.30E-02	3.87E-04	1.65E-06	6.91E-04	8.15E-05	2.98E-10	1.44E-06	9.94E-09	9.29E-09
SD01-2	62	844	1.02E-02	2.91E-04	1.37E-06	5.61E-04	6.21E-05	2.18E-10	1.21E-06	7.91E-09	7.45E-09
SD01-2	63	844	1.25E-02	3.42E-04	1.76E-06	7.07E-04	7.40E-05	2.49E-10	1.58E-06	9.84E-09	9.31E-09
SD01-2	64	844	1.23E-02	3.20E-04	1.82E-06	7.11E-04	7.04E-05	2.25E-10	1.65E-06	9.78E-09	9.31E-09
SD01-2	65	820	7.82E-05	2.15E-06	1.58E-08	5.64E-06	4.96E-07	1.39E-12	1.45E-08	7.71E-11	7.43E-11
SD01-2	66	821	6.48E-05	1.79E-06	1.31E-08	4.68E-06	4.11E-07	1.15E-12	1.20E-08	6.39E-11	6.16E-11
SD01-2	67	844	9.63E-03	2.40E-04	1.50E-06	5.69E-04	5.40E-05	1.64E-10	1.37E-06	7.78E-09	7.44E-09
SD01-2	68	844	9.47E-03	2.27E-04	1.54E-06	5.68E-04	5.17E-05	1.52E-10	1.41E-06	7.74E-09	7.43E-09
SD01-2	69	844	1.16E-02	2.66E-04	1.97E-06	7.06E-04	6.17E-05	1.73E-10	1.81E-06	9.61E-09	9.27E-09
SD01-2	70	844	1.13E-02	2.48E-04	2.02E-06	6.98E-04	5.87E-05	1.56E-10	1.86E-06	9.54E-09	9.24E-09
SD01-2	71	844	8.89E-03	1.87E-04	1.64E-06	5.53E-04	4.47E-05	1.14E-10	1.52E-06	7.59E-09	7.37E-09
SD01-2	72	844	1.09E-02	2.20E-04	2.09E-06	6.82E-04	5.33E-05	1.30E-10	1.94E-06	9.42E-09	9.18E-09
SD01-2	73	820	6.65E-05	1.45E-06	1.67E-08	4.99E-06	3.65E-07	7.82E-13	1.54E-08	7.09E-11	6.96E-11
SD01-2	74	821	5.51E-05	1.20E-06	1.38E-08	4.14E-06	3.03E-07	6.47E-13	1.28E-08	5.88E-11	5.77E-11

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD01-2	75	844	8.52E-03	1.66E-04	1.70E-06	5.37E-04	4.08E-05	9.51E-11	1.58E-06	7.49E-09	7.32E-09
SD01-2	76	844	8.35E-03	1.58E-04	1.72E-06	5.30E-04	3.93E-05	8.77E-11	1.60E-06	7.44E-09	7.29E-09
SD01-2	77	844	1.02E-02	1.87E-04	2.18E-06	6.51E-04	4.73E-05	1.00E-10	2.02E-06	9.24E-09	9.08E-09
SD01-2	78	844	9.95E-03	1.76E-04	2.20E-06	6.38E-04	4.56E-05	9.04E-11	2.03E-06	9.18E-09	9.03E-09
SD01-2	79	844	7.78E-03	1.33E-04	1.77E-06	5.01E-04	3.54E-05	6.61E-11	1.63E-06	7.29E-09	7.20E-09
SD01-2	80	844	7.62E-03	1.27E-04	1.77E-06	4.93E-04	3.45E-05	6.09E-11	1.64E-06	7.25E-09	7.17E-09
SD01-2	81	820	5.60E-05	1.03E-06	1.61E-08	4.30E-06	3.00E-07	4.41E-13	1.50E-08	6.58E-11	6.53E-11
SD01-2	82	821	4.64E-05	8.51E-07	1.34E-08	3.56E-06	2.49E-07	3.55E-13	1.24E-08	5.45E-11	5.41E-11
SD01-2	83	844	9.30E-03	1.51E-04	2.20E-06	6.04E-04	4.21E-05	6.95E-11	2.04E-06	9.01E-09	8.92E-09
SD01-2	84	844	9.05E-03	1.43E-04	2.19E-06	5.91E-04	4.12E-05	6.29E-11	2.04E-06	8.95E-09	8.88E-09
SD01-2	85	844	7.07E-03	1.09E-04	1.75E-06	4.64E-04	3.23E-05	4.60E-11	1.62E-06	7.12E-09	7.07E-09
SD01-2	86	844	8.62E-03	1.31E-04	2.17E-06	5.70E-04	3.98E-05	5.25E-11	2.02E-06	8.85E-09	8.80E-09
SD01-2	87	844	6.72E-03	9.99E-05	1.73E-06	4.47E-04	3.14E-05	3.84E-11	1.60E-06	7.04E-09	7.01E-09
SD01-2	88	844	6.57E-03	9.62E-05	1.73E-06	4.40E-04	3.11E-05	3.54E-11	1.59E-06	7.01E-09	6.99E-09
SD01-2	89	820	4.68E-05	7.49E-07	1.52E-08	3.73E-06	2.73E-07	2.27E-13	1.36E-08	6.17E-11	6.17E-11
SD01-2	90	844	8.01E-03	1.15E-04	2.15E-06	5.41E-04	3.86E-05	4.05E-11	1.96E-06	8.72E-09	8.70E-09
SD01-2	91	844	7.78E-03	1.10E-04	2.14E-06	5.30E-04	3.84E-05	3.66E-11	1.93E-06	8.68E-09	8.67E-09
SD01-2	92	844	6.06E-03	8.36E-05	1.70E-06	4.17E-04	3.07E-05	2.67E-11	1.52E-06	6.92E-09	6.92E-09
SD01-2	93	844	7.38E-03	9.87E-05	2.12E-06	5.13E-04	3.81E-05	3.06E-11	1.87E-06	8.62E-09	8.63E-09
SD01-2	94	844	5.75E-03	7.47E-05	1.69E-06	4.04E-04	3.03E-05	2.24E-11	1.47E-06	6.87E-09	6.89E-09
SD01-2	95	844	6.99E-03	8.84E-05	2.10E-06	4.98E-04	3.77E-05	2.56E-11	1.81E-06	8.58E-09	8.61E-09
SD01-2	96	844	5.44E-03	6.67E-05	1.67E-06	3.91E-04	2.94E-05	1.85E-11	1.41E-06	6.83E-09	6.85E-09
SD01-2	97	844	6.61E-03	7.96E-05	2.10E-06	4.84E-04	3.62E-05	2.13E-11	1.74E-06	8.59E-09	8.63E-09
SD01-2	98	844	5.14E-03	6.06E-05	1.69E-06	3.82E-04	2.85E-05	1.56E-11	1.36E-06	6.90E-09	6.94E-09
SD01-2	99	844	5.01E-03	5.80E-05	1.71E-06	3.78E-04	2.83E-05	1.44E-11	1.33E-06	6.94E-09	6.99E-09
SD01-2	100	844	6.09E-03	6.92E-05	2.17E-06	4.67E-04	3.53E-05	1.64E-11	1.64E-06	8.76E-09	8.83E-09
SD01-2	101	844	4.73E-03	5.23E-05	1.78E-06	3.61E-04	2.84E-05	1.20E-11	1.29E-06	7.11E-09	7.17E-09

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD01-2	102	820	3.18E-05	3.69E-07	1.69E-08	2.70E-06	2.72E-07	7.11E-14	9.65E-06	6.29E-11	6.36E-11
SD01-2	103	821	2.64E-05	3.06E-07	1.40E-08	2.24E-06	2.25E-07	7.11E-14	7.99E-06	5.21E-11	5.27E-11
SD01-2	104	844	5.74E-03	6.17E-05	2.30E-06	4.35E-04	3.61E-05	1.38E-11	1.62E-06	9.03E-09	9.11E-09
SD01-2	105	844	4.46E-03	4.66E-05	1.90E-06	3.35E-04	2.97E-05	1.01E-11	1.34E-06	7.37E-09	7.44E-09
SD01-2	106	844	5.55E-03	5.64E-05	2.52E-06	4.13E-04	3.95E-05	1.19E-11	1.88E-06	9.60E-09	9.70E-09
SD01-2	107	844	4.21E-03	4.15E-05	2.03E-06	3.10E-04	3.26E-05	8.44E-12	1.74E-06	7.62E-09	7.70E-09
SD01-2	108	844	5.05E-03	4.86E-05	2.62E-06	3.69E-04	4.48E-05	9.62E-12	3.01E-06	9.64E-09	9.75E-09
SD01-2	109	844	4.13E-03	3.60E-05	3.21E-06	2.79E-04	4.20E-05	8.23E-12	1.37E-02	7.68E-09	7.77E-09
SD01-2	110	820	2.58E-05	1.72E-07	1.85E-08	9.14E-07	1.69E-07	4.69E-13	4.12E-05	3.54E-11	3.58E-11
SD01-2	111	821	2.14E-05	1.42E-07	1.54E-08	7.58E-07	1.40E-07	3.77E-13	3.42E-05	2.93E-11	2.97E-11
SD01-2	112	824	1.16E-05	7.71E-08	8.33E-09	4.11E-07	7.58E-08	1.99E-13	1.85E-05	1.59E-11	1.61E-11
SD01-2	113	844	4.99E-03	3.10E-05	4.94E-06	2.32E-04	4.45E-05	1.62E-11	1.36E-02	6.89E-09	6.97E-09
SD01-2	114	844	3.94E-03	2.04E-05	2.64E-06	1.34E-04	2.81E-05	2.77E-11	6.71E-03	4.51E-09	4.56E-09
SD01-2	115	844	4.77E-03	2.49E-05	2.69E-06	1.34E-04	2.75E-05	6.73E-11	5.70E-03	5.37E-09	5.43E-09
SD01-2	116	844	4.47E-03	2.66E-05	2.31E-06	1.13E-04	2.08E-05	9.14E-11	3.91E-03	5.30E-09	5.36E-09
SD01-2	117	844	3.55E-03	2.52E-05	1.90E-06	8.77E-05	1.41E-05	1.12E-10	2.47E-03	4.82E-09	4.87E-09
SD01-2	118	844	3.43E-03	2.91E-05	1.96E-06	8.57E-05	1.21E-05	1.43E-10	2.01E-03	5.27E-09	5.33E-09
SD01-2	119	820	2.06E-05	3.65E-07	1.64E-08	6.76E-07	6.15E-08	1.58E-12	8.79E-06	4.99E-11	5.07E-11
SD01-2	120	821	1.71E-05	3.02E-07	1.36E-08	5.60E-07	5.10E-08	1.29E-12	7.29E-06	4.14E-11	4.20E-11
SD01-2	121	844	4.17E-03	4.33E-05	2.59E-06	1.08E-04	1.32E-05	2.22E-10	2.06E-03	7.33E-09	7.41E-09
SD01-2	122	844	3.30E-03	4.18E-05	2.21E-06	8.99E-05	9.43E-06	2.05E-10	1.40E-03	6.49E-09	6.57E-09
SD01-2	123	844	4.03E-03	6.22E-05	2.87E-06	1.17E-04	1.06E-05	2.76E-10	1.50E-03	8.74E-09	8.86E-09
SD01-2	124	844	3.72E-03	7.03E-05	2.83E-06	1.16E-04	9.05E-06	2.78E-10	1.20E-03	8.88E-09	9.02E-09
SD01-2	125	844	2.88E-03	6.42E-05	2.41E-06	9.63E-05	6.68E-06	2.51E-10	8.38E-04	7.71E-09	7.84E-09
SD01-2	126	844	2.82E-03	7.20E-05	2.58E-06	1.01E-04	6.32E-06	2.80E-10	7.53E-04	8.34E-09	8.49E-09
SD01-2	127	820	1.64E-05	5.24E-07	2.08E-08	8.71E-07	4.18E-08	1.20E-10	3.72E-06	1.22E-10	7.71E-11
SD01-2	128	821	1.36E-05	4.34E-07	1.72E-08	7.22E-07	3.46E-08	9.97E-11	3.08E-06	1.01E-10	6.39E-11

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD01-2	129	844	3.41E-03	1.01E-04	3.43E-06	1.31E-04	7.44E-06	3.86E-10	8.34E-04	1.12E-08	1.14E-08
SD01-2	130	844	3.28E-03	1.05E-04	3.64E-06	1.37E-04	7.01E-06	4.24E-10	7.31E-04	1.20E-08	1.22E-08
SD01-2	131	844	2.60E-03	7.68E-05	3.02E-06	1.16E-04	5.46E-06	3.46E-10	5.31E-04	1.01E-08	1.03E-08
SD01-2	132	844	2.39E-03	6.56E-05	2.94E-06	1.12E-04	4.79E-06	3.43E-10	4.47E-04	9.93E-09	1.02E-08
SD01-2	133	844	2.05E-03	5.41E-05	2.42E-06	1.13E-04	5.43E-06	4.97E-08	3.25E-04	3.03E-08	1.10E-08
SD01-2	134	844	1.32E-03	2.72E-05	1.42E-06	7.19E-05	3.03E-06	2.52E-08	1.55E-04	1.60E-08	6.30E-09
SD01-2	135	820	1.42E-05	3.37E-07	2.50E-08	1.16E-06	4.85E-08	2.91E-10	1.78E-06	2.16E-10	1.05E-10
SD01-2	136	821	1.18E-05	2.79E-07	2.07E-08	9.65E-07	4.02E-08	2.41E-10	1.47E-06	1.79E-10	8.71E-11
SD01-2	137	824	6.38E-06	1.51E-07	1.12E-08	5.23E-07	2.18E-08	1.31E-10	7.99E-07	9.70E-11	4.72E-11
SD01-2	138	844	1.02E-03	1.97E-05	1.17E-06	5.72E-05	2.41E-06	1.79E-08	1.10E-04	1.20E-08	5.09E-09
SD01-2	139	844	1.26E-03	2.28E-05	1.54E-06	7.26E-05	3.05E-06	2.02E-08	1.24E-04	1.43E-08	6.54E-09
SD01-2	140	844	9.95E-04	1.71E-05	1.29E-06	5.94E-05	2.49E-06	1.48E-08	9.03E-05	1.10E-08	5.41E-09
SD01-2	141	844	1.23E-03	2.01E-05	1.68E-06	7.58E-05	3.17E-06	1.69E-08	1.03E-04	1.33E-08	6.95E-09
SD01-2	142	844	9.65E-04	1.51E-05	1.39E-06	6.19E-05	2.58E-06	1.23E-08	7.47E-05	1.03E-08	5.71E-09
SD01-2	143	844	9.57E-04	1.44E-05	1.44E-06	6.34E-05	2.64E-06	1.14E-08	6.92E-05	1.01E-08	5.87E-09
SD01-2	144	820	1.28E-05	2.35E-07	2.83E-08	1.25E-06	5.90E-08	3.61E-10	1.03E-06	2.48E-10	1.23E-10
SD01-2	145	821	1.06E-05	1.95E-07	2.35E-08	1.03E-06	4.89E-08	2.99E-10	8.56E-07	2.05E-10	1.02E-10
SD01-2	146	824	5.75E-06	1.06E-07	1.27E-08	5.59E-07	2.65E-08	1.62E-10	4.64E-07	1.11E-10	5.53E-11
SD01-2	147	844	1.19E-03	1.74E-05	1.87E-06	8.24E-05	3.43E-06	1.33E-08	8.04E-05	1.25E-08	7.61E-09
SD01-2	148	844	9.30E-04	1.30E-05	1.52E-06	6.64E-05	2.76E-06	9.60E-09	5.79E-05	9.64E-09	6.14E-09
SD01-2	149	844	1.15E-03	1.55E-05	1.94E-06	8.48E-05	3.52E-06	1.10E-08	6.62E-05	1.18E-08	7.85E-09
SD01-2	150	844	1.10E-03	1.47E-05	1.89E-06	8.23E-05	4.06E-06	2.65E-08	6.24E-05	1.74E-08	8.35E-09
SD01-2	151	844	7.24E-04	8.41E-06	1.10E-06	4.82E-05	2.71E-06	2.38E-08	3.56E-05	1.32E-08	5.27E-09
SD01-2	152	844	7.65E-04	8.57E-06	1.05E-06	4.62E-05	3.49E-06	4.59E-08	3.86E-05	2.13E-08	6.07E-09
SD01-2	153	820	1.20E-05	1.82E-07	2.56E-08	1.18E-06	8.18E-08	9.72E-10	7.16E-07	4.66E-10	1.45E-10
SD01-2	154	821	9.97E-06	1.51E-07	2.12E-08	9.77E-07	6.77E-08	8.05E-10	5.93E-07	3.86E-10	1.20E-10
SD01-2	155	824	5.40E-06	8.16E-08	1.15E-08	5.29E-07	3.67E-08	4.36E-10	3.21E-07	2.09E-10	6.49E-11

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD01-2	156	844	2.87E-04	1.23E-06	1.57E-07	6.93E-06	5.40E-07	7.36E-09	5.42E-06	3.37E-09	9.31E-10
SD01-2	157	844	4.20E-04	2.48E-06	3.34E-07	1.51E-05	1.10E-06	1.40E-08	1.03E-05	6.57E-09	1.93E-09
SD01-2	158	844	2.27E-04	6.94E-07	9.85E-08	4.59E-06	3.15E-07	3.68E-09	2.71E-06	1.77E-09	5.56E-10
SD01-2	159	844	2.62E-04	9.21E-07	1.37E-07	6.39E-06	4.20E-07	4.64E-09	3.41E-06	2.28E-09	7.53E-10
SD01-2	160	844	3.27E-04	1.14E-06	1.79E-07	8.42E-06	5.30E-07	5.42E-09	4.00E-06	2.74E-09	9.61E-10
SD01-2	161	844	3.24E-04	1.11E-06	1.83E-07	8.69E-06	5.21E-07	4.89E-09	3.59E-06	2.56E-09	9.58E-10
SD01-2	162	820	1.17E-05	1.64E-07	2.94E-08	1.46E-06	7.97E-08	5.89E-10	4.32E-07	3.38E-10	1.48E-10
SD01-2	163	821	9.68E-06	1.36E-07	2.43E-08	1.21E-06	6.60E-08	4.88E-10	3.58E-07	2.80E-10	1.22E-10
SD01-2	164	824	5.24E-06	7.35E-08	1.32E-08	6.54E-07	3.58E-08	2.64E-10	1.94E-07	1.52E-10	6.63E-11
SD01-2	165	844	2.57E-04	8.61E-07	1.49E-07	7.10E-06	4.11E-07	3.56E-09	2.62E-06	1.92E-09	7.62E-10
SD01-2	166	844	2.55E-04	8.47E-07	1.50E-07	7.22E-06	4.06E-07	3.27E-09	2.39E-06	1.82E-09	7.57E-10
SD01-2	167	844	3.98E-04	2.01E-06	3.65E-07	1.80E-05	9.84E-07	7.24E-09	5.33E-06	4.17E-09	1.83E-09
SD01-2	168	844	1.91E-04	4.02E-07	7.34E-08	3.75E-06	1.99E-07	1.34E-09	9.72E-07	7.96E-10	3.67E-10
SD01-2	169	844	3.10E-04	1.28E-06	2.37E-07	1.22E-05	6.38E-07	4.01E-09	2.94E-06	2.46E-09	1.18E-09
SD01-2	170	844	2.41E-04	7.28E-07	1.39E-07	7.23E-06	3.68E-07	2.11E-09	1.55E-06	1.35E-09	6.84E-10
SD01-2	171	820	1.13E-05	1.57E-07	3.15E-08	1.68E-06	7.98E-08	3.60E-10	2.63E-07	2.62E-10	1.51E-10
SD01-2	172	821	9.40E-06	1.30E-07	2.61E-08	1.39E-06	6.61E-08	2.99E-10	2.18E-07	2.17E-10	1.25E-10
SD01-2	173	824	5.09E-06	7.05E-08	1.41E-08	7.52E-07	3.58E-08	1.62E-10	1.18E-07	1.18E-10	6.76E-11
SD01-2	174	844	3.01E-04	9.22E-07	1.80E-07	9.40E-06	4.67E-07	2.47E-09	1.81E-06	1.65E-09	8.73E-10
SD01-2	175	844	2.99E-04	9.17E-07	1.82E-07	9.62E-06	4.65E-07	2.26E-09	1.66E-06	1.58E-09	8.78E-10
SD01-2	176	844	2.38E-04	7.28E-07	1.47E-07	7.84E-06	3.72E-07	1.67E-09	1.22E-06	1.22E-09	7.04E-10
SD01-2	177	844	2.35E-04	7.13E-07	1.46E-07	7.82E-06	3.65E-07	1.52E-09	1.11E-06	1.16E-09	6.94E-10
SD01-2	178	844	3.12E-04	1.42E-06	2.93E-07	1.59E-05	7.30E-07	2.79E-09	2.02E-06	2.23E-09	1.39E-09
SD01-2	179	844	2.84E-04	8.27E-07	1.72E-07	9.46E-06	4.27E-07	1.49E-09	1.10E-06	1.26E-09	8.13E-10
SD01-2	180	820	1.10E-05	1.55E-07	3.27E-08	1.84E-06	8.07E-08	2.22E-10	1.61E-07	2.17E-10	1.53E-10
SD01-2	181	821	9.12E-06	1.28E-07	2.71E-08	1.52E-06	6.69E-08	1.84E-10	1.33E-07	1.80E-10	1.27E-10
SD01-2	182	824	4.94E-06	6.96E-08	1.47E-08	8.25E-07	3.62E-08	9.97E-11	7.23E-08	9.73E-11	6.87E-11

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD01-2	183	844	2.29E-04	6.82E-07	1.43E-07	7.90E-06	3.53E-07	1.14E-09	8.20E-07	1.01E-09	6.71E-10
SD01-2	184	844	2.29E-04	6.89E-07	1.45E-07	8.10E-06	3.58E-07	1.07E-09	7.82E-07	9.94E-10	6.82E-10
SD01-2	185	844	2.85E-04	8.66E-07	1.83E-07	1.03E-05	4.52E-07	1.24E-09	9.09E-07	1.21E-09	8.58E-10
SD01-2	186	844	2.27E-04	6.89E-07	1.47E-07	8.34E-06	3.62E-07	9.19E-10	6.59E-07	9.46E-10	6.87E-10
SD01-2	187	844	2.83E-04	8.97E-07	1.92E-07	1.09E-05	4.72E-07	1.10E-09	7.93E-07	1.20E-09	8.93E-10
SD01-2	188	844	2.83E-04	1.45E-06	3.11E-07	1.78E-05	7.67E-07	1.63E-09	1.18E-06	1.89E-09	1.45E-09
SD01-2	189	844	2.83E-04	1.37E-06	2.87E-07	1.70E-05	7.32E-07	1.46E-09	1.06E-06	1.74E-09	1.36E-09
SD01-2	190	844	2.15E-04	5.96E-07	1.24E-07	7.50E-06	3.20E-07	5.73E-10	4.10E-07	7.36E-10	5.90E-10
SD01-2	191	844	2.72E-04	8.69E-07	1.81E-07	1.10E-05	4.68E-07	7.74E-10	5.59E-07	1.05E-09	8.61E-10
SD01-8	1	820	9.18E-05	4.35E-06	5.75E-08	3.95E-06	4.11E-06	1.20E-07	1.09E-06	2.07E-12	2.07E-12
SD01-8	2	821	7.61E-05	3.61E-06	4.77E-08	3.28E-06	3.41E-06	9.97E-08	9.06E-07	1.72E-12	1.72E-12
SD01-8	3	824	4.12E-05	1.96E-06	2.60E-08	1.78E-06	1.86E-06	5.42E-08	4.93E-07	9.34E-13	9.37E-13
SD01-8	4	820	1.62E-04	3.20E-07	3.21E-07	5.89E-07	2.45E-07	1.12E-08	3.47E-08	3.73E-08	6.70E-10
SD01-8	5	821	1.35E-04	3.20E-07	3.96E-07	5.67E-07	2.24E-07	1.05E-08	3.14E-08	4.39E-08	8.00E-10
SD01-8	6	824	7.33E-05	1.74E-07	2.17E-07	3.09E-07	1.22E-07	5.70E-09	1.71E-08	2.40E-08	4.38E-10
SD01-8	7	820	1.70E-04	1.17E-08	1.53E-08	6.57E-08	1.62E-08	1.70E-10	4.25E-10	1.57E-09	4.22E-11
SD01-8	8	821	1.41E-04	9.65E-09	1.27E-08	5.45E-08	1.35E-08	1.40E-10	3.52E-10	1.30E-09	3.49E-11
SD01-8	9	824	7.65E-05	5.23E-09	6.85E-09	2.96E-08	7.31E-09	7.60E-11	1.91E-10	7.02E-10	1.89E-11
SD01-8	10	820	1.69E-04	9.93E-09	3.81E-09	8.32E-08	7.12E-08	4.37E-11	2.53E-10	2.81E-10	2.76E-11
SD01-8	11	821	1.40E-04	8.23E-09	3.16E-09	6.89E-08	5.90E-08	3.62E-11	2.10E-10	2.33E-10	2.29E-11
SD01-8	12	820	1.73E-04	2.18E-08	1.52E-08	7.03E-08	3.07E-08	2.27E-10	1.16E-09	1.54E-09	5.05E-11
SD01-8	13	821	1.44E-04	1.84E-08	1.29E-08	5.91E-08	2.58E-08	1.95E-10	9.93E-10	1.32E-09	4.27E-11
SD01-8	14	824	7.84E-05	1.00E-08	6.99E-09	3.23E-08	1.40E-08	1.06E-10	5.44E-10	7.12E-10	2.31E-11
SD01-8	15	820	1.72E-04	2.36E-08	2.86E-09	9.87E-08	2.90E-08	5.16E-11	7.69E-10	2.76E-10	3.26E-11
SD01-8	16	821	1.43E-04	1.95E-08	2.37E-09	8.18E-08	2.41E-08	4.27E-11	6.38E-10	2.29E-10	2.70E-11
SD01-8	17	820	1.76E-04	2.50E-08	1.20E-09	1.25E-07	3.47E-08	1.79E-11	1.03E-09	7.23E-11	3.11E-11
SD01-8	18	821	1.46E-04	2.07E-08	9.94E-10	1.04E-07	2.88E-08	1.49E-11	8.54E-10	5.99E-11	2.58E-11

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD01-8	19	820	1.86E-04	6.01E-08	2.24E-09	2.35E-07	6.85E-08	1.11E-11	1.06E-09	7.95E-11	5.87E-11
SD01-8	20	821	1.54E-04	4.98E-08	1.86E-09	1.95E-07	5.68E-08	9.17E-12	8.80E-10	6.59E-11	4.87E-11
SD01-8	21	820	1.51E-04	5.74E-08	2.73E-09	1.96E-07	8.16E-08	1.43E-11	1.98E-09	7.86E-11	6.24E-11
SD01-8	22	821	1.25E-04	4.76E-08	2.26E-09	1.62E-07	6.77E-08	1.18E-11	1.64E-09	6.52E-11	5.17E-11
SD01-8	23	844	1.02E-01	4.07E-05	1.93E-06	1.21E-04	5.42E-05	1.56E-08	2.77E-06	5.55E-08	4.20E-08
SD01-8	24	844	2.58E-01	1.25E-04	5.41E-06	3.43E-04	1.80E-04	4.98E-08	1.08E-05	1.56E-07	1.16E-07
SD01-8	25	844	2.12E-01	1.35E-04	4.78E-06	4.07E-04	2.01E-04	4.56E-08	1.15E-05	1.41E-07	1.06E-07
SD01-8	26	844	7.39E-02	7.78E-05	1.78E-06	2.42E-04	9.01E-05	1.67E-08	5.15E-06	5.60E-08	4.36E-08
SD01-8	27	844	3.65E-02	7.01E-05	5.47E-06	1.91E-04	5.43E-05	7.93E-09	3.11E-06	3.14E-08	2.55E-08
SD01-8	28	844	1.86E-02	6.27E-05	1.18E-05	1.52E-04	3.40E-05	3.81E-09	1.96E-06	1.81E-08	1.53E-08
SD01-8	29	844	1.97E-02	1.02E-04	2.78E-05	2.13E-04	4.44E-05	3.84E-09	2.65E-06	2.15E-08	1.87E-08
SD01-8	30	844	1.41E-02	1.03E-04	3.51E-05	1.87E-04	3.93E-05	2.62E-09	2.38E-06	1.71E-08	1.52E-08
SD01-8	31	844	1.62E-02	1.56E-04	5.64E-05	2.66E-04	5.43E-05	2.84E-09	3.35E-06	2.14E-08	1.94E-08
SD01-8	32	844	1.21E-02	1.48E-04	3.79E-05	2.41E-04	4.36E-05	1.98E-09	3.00E-06	1.73E-08	1.59E-08
SD01-8	33	844	1.41E-02	2.01E-04	3.96E-05	3.31E-04	5.54E-05	2.16E-09	4.16E-06	2.18E-08	2.03E-08
SD01-8	34	844	1.06E-02	1.48E-04	2.67E-05	2.83E-04	4.57E-05	1.51E-09	3.64E-06	1.77E-08	1.66E-08
SD01-8	35	844	1.25E-02	1.67E-04	2.81E-05	3.71E-04	5.91E-05	1.63E-09	4.88E-06	2.21E-08	2.10E-08
SD01-8	36	844	9.42E-03	1.22E-04	1.91E-05	3.11E-04	4.96E-05	1.13E-09	4.19E-06	1.78E-08	1.70E-08
SD01-8	37	844	1.11E-02	1.40E-04	2.02E-05	4.03E-04	6.43E-05	1.21E-09	5.57E-06	2.23E-08	2.14E-08
SD01-8	38	844	8.44E-03	1.04E-04	1.38E-05	3.33E-04	5.26E-05	8.38E-10	4.72E-06	1.79E-08	1.73E-08
SD01-8	39	844	9.98E-03	1.21E-04	1.47E-05	4.27E-04	6.75E-05	9.00E-10	6.21E-06	2.23E-08	2.17E-08
SD01-8	40	844	7.54E-03	9.05E-05	1.00E-05	3.47E-04	5.57E-05	6.17E-10	5.20E-06	1.78E-08	1.73E-08
SD01-8	41	844	8.92E-03	1.07E-04	1.08E-05	4.40E-04	7.24E-05	6.62E-10	6.78E-06	2.21E-08	2.16E-08
SD01-8	42	844	6.76E-03	8.08E-05	7.38E-06	3.55E-04	6.05E-05	4.54E-10	5.64E-06	1.75E-08	1.72E-08
SD01-8	43	844	8.00E-03	9.62E-05	7.95E-06	4.46E-04	7.94E-05	4.88E-10	7.32E-06	2.18E-08	2.14E-08
SD01-8	44	844	6.07E-03	7.36E-05	5.49E-06	3.57E-04	6.71E-05	3.35E-10	6.06E-06	1.73E-08	1.71E-08
SD01-8	45	844	7.19E-03	8.85E-05	5.95E-06	4.46E-04	8.89E-05	3.60E-10	7.82E-06	2.14E-08	2.12E-08

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD01-8	46	844	5.45E-03	6.83E-05	4.14E-06	3.55E-04	7.56E-05	2.47E-10	6.45E-06	1.70E-08	1.69E-08
SD01-8	47	844	6.47E-03	8.28E-05	4.52E-06	4.41E-04	1.01E-04	2.66E-10	8.28E-06	2.11E-08	2.09E-08
SD01-8	48	844	4.91E-03	6.43E-05	3.22E-06	3.50E-04	8.64E-05	1.83E-10	6.80E-06	1.67E-08	1.66E-08
SD01-8	49	844	5.82E-03	7.84E-05	4.99E-06	4.33E-04	1.16E-04	1.97E-10	8.70E-06	2.07E-08	2.06E-08
SD01-8	50	844	4.41E-03	6.13E-05	4.89E-06	3.42E-04	9.96E-05	1.35E-10	7.12E-06	1.64E-08	1.64E-08
SD01-8	51	844	5.23E-03	7.50E-05	7.26E-06	4.22E-04	1.34E-04	1.46E-10	9.08E-06	2.04E-08	2.03E-08
SD01-8	52	844	3.97E-03	5.89E-05	6.77E-06	3.33E-04	1.13E-04	1.00E-10	7.40E-06	1.61E-08	1.61E-08
SD01-8	53	844	4.71E-03	7.23E-05	9.69E-06	4.10E-04	1.45E-04	1.08E-10	9.41E-06	2.00E-08	2.00E-08
SD01-8	54	844	3.57E-03	5.69E-05	8.76E-06	3.22E-04	1.21E-04	7.45E-11	7.64E-06	1.59E-08	1.59E-08
SD01-8	55	844	4.24E-03	7.01E-05	1.23E-05	3.96E-04	1.57E-04	8.02E-11	9.68E-06	1.97E-08	1.97E-08
SD01-8	56	844	3.21E-03	5.53E-05	1.09E-05	3.11E-04	1.31E-04	5.53E-11	7.83E-06	1.56E-08	1.56E-08
SD01-8	57	844	3.81E-03	6.81E-05	1.51E-05	3.82E-04	1.72E-04	5.96E-11	9.88E-06	1.93E-08	1.94E-08
SD01-8	58	844	2.89E-03	5.38E-05	1.34E-05	3.00E-04	1.45E-04	4.10E-11	7.96E-06	1.53E-08	1.54E-08
SD01-8	59	844	3.42E-03	6.63E-05	1.81E-05	3.67E-04	1.90E-04	4.42E-11	1.00E-05	1.90E-08	1.91E-08
SD01-8	60	844	2.59E-03	5.23E-05	1.51E-05	2.88E-04	1.52E-04	3.05E-11	8.04E-06	1.51E-08	1.52E-08
SD01-8	61	844	3.07E-03	6.46E-05	1.93E-05	3.53E-04	1.80E-04	3.28E-11	1.01E-05	1.88E-08	1.89E-08
SD01-8	62	844	2.32E-03	5.10E-05	1.41E-05	2.77E-04	1.38E-04	2.26E-11	8.07E-06	1.50E-08	1.50E-08
SD01-8	63	844	2.19E-03	4.98E-05	1.28E-05	2.68E-04	1.33E-04	1.96E-11	7.98E-06	1.47E-08	1.48E-08
SD01-8	64	844	2.58E-03	6.13E-05	1.48E-05	3.28E-04	1.61E-04	2.11E-11	9.95E-06	1.83E-08	1.84E-08
SD01-8	65	844	2.43E-03	6.05E-05	1.39E-05	3.21E-04	1.57E-04	1.79E-11	9.93E-06	1.83E-08	1.84E-08
SD01-8	66	844	1.84E-03	4.78E-05	1.06E-05	2.52E-04	1.24E-04	1.24E-11	7.92E-06	1.46E-08	1.47E-08
SD01-8	67	844	2.18E-03	5.89E-05	1.28E-05	3.08E-04	1.55E-04	1.33E-11	9.86E-06	1.83E-08	1.84E-08
SD01-8	68	844	1.65E-03	4.65E-05	9.86E-06	2.42E-04	1.24E-04	9.19E-12	7.86E-06	1.47E-08	1.48E-08
SD01-8	69	844	1.95E-03	5.73E-05	1.20E-05	2.96E-04	1.55E-04	9.96E-12	9.77E-06	1.85E-08	1.87E-08
SD01-8	70	844	1.47E-03	4.53E-05	9.43E-06	2.32E-04	1.24E-04	6.88E-12	7.77E-06	1.50E-08	1.51E-08
SD01-8	71	844	1.74E-03	5.58E-05	1.16E-05	2.84E-04	1.58E-04	7.43E-12	9.66E-06	1.90E-08	1.92E-08
SD01-8	72	844	1.31E-03	4.38E-05	8.26E-06	2.23E-04	1.30E-04	5.17E-12	7.64E-06	1.55E-08	1.57E-08

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD01-8	73	844	1.55E-03	5.29E-05	9.24E-06	2.73E-04	1.68E-04	5.64E-12	9.27E-06	1.99E-08	2.01E-08
SD01-8	74	844	1.17E-03	4.10E-05	6.67E-06	2.14E-04	1.42E-04	3.95E-12	7.31E-06	1.63E-08	1.64E-08
SD01-8	75	844	1.38E-03	4.87E-05	7.58E-06	2.63E-04	1.90E-04	4.36E-12	8.95E-06	2.09E-08	2.11E-08
SD01-8	76	844	1.04E-03	3.54E-05	5.56E-06	2.07E-04	1.66E-04	3.15E-12	6.87E-06	1.71E-08	1.73E-08
SD01-8	77	844	9.87E-04	3.26E-05	5.19E-06	2.03E-04	1.85E-04	2.94E-12	7.23E-06	1.75E-08	1.77E-08
SD01-8	78	844	1.17E-03	3.60E-05	5.85E-06	2.40E-04	2.64E-04	1.15E-11	1.30E-02	2.16E-08	2.18E-08
SD01-8	79	844	1.13E-03	2.07E-05	4.01E-06	1.49E-04	1.95E-04	1.78E-10	2.58E-02	1.57E-08	1.58E-08
SD01-8	80	844	8.56E-04	1.17E-05	3.11E-06	9.17E-05	1.03E-04	2.37E-10	1.27E-02	1.12E-08	1.13E-08
SD01-8	81	844	1.04E-03	1.24E-05	4.40E-06	1.05E-04	9.37E-05	2.88E-10	1.12E-02	1.33E-08	1.34E-08
SD01-8	82	844	7.90E-04	9.04E-06	4.29E-06	8.27E-05	5.63E-05	2.17E-10	6.61E-03	1.05E-08	1.05E-08
SD01-8	83	844	9.26E-04	1.10E-05	6.77E-06	1.06E-04	5.44E-05	2.72E-10	6.25E-03	1.33E-08	1.34E-08
SD01-8	84	844	7.07E-04	9.08E-06	7.05E-06	9.17E-05	3.52E-05	2.22E-10	3.96E-03	1.13E-08	1.14E-08
SD01-8	85	844	8.30E-04	1.19E-05	1.12E-05	1.23E-04	3.56E-05	2.34E-10	3.95E-03	1.44E-08	1.45E-08
SD01-8	86	844	6.13E-04	9.93E-06	9.31E-06	1.04E-04	2.31E-05	1.97E-10	2.50E-03	1.20E-08	1.21E-08
SD01-8	87	844	7.13E-04	1.32E-05	1.01E-05	1.40E-04	2.54E-05	4.36E-10	2.55E-03	1.76E-08	1.77E-08
SD01-8	88	844	5.37E-04	1.14E-05	7.40E-06	1.21E-04	1.83E-05	4.85E-10	1.69E-03	1.61E-08	1.62E-08
SD01-8	89	844	6.32E-04	1.54E-05	8.63E-06	1.63E-04	2.10E-05	7.39E-10	1.78E-03	2.23E-08	2.24E-08
SD01-8	90	844	4.73E-04	1.33E-05	6.48E-06	1.40E-04	1.54E-05	6.61E-10	1.19E-03	1.92E-08	1.93E-08
SD01-8	91	844	5.53E-04	1.78E-05	7.80E-06	1.86E-04	1.79E-05	9.55E-10	1.26E-03	2.60E-08	2.61E-08
SD01-8	92	844	4.14E-04	1.53E-05	6.07E-06	1.57E-04	1.31E-05	8.56E-10	8.53E-04	2.23E-08	2.24E-08
SD01-8	93	844	4.92E-04	2.08E-05	7.32E-06	2.11E-04	1.47E-05	1.08E-09	9.19E-04	2.89E-08	2.91E-08
SD01-8	94	844	3.62E-04	1.74E-05	5.62E-06	1.74E-04	1.02E-05	8.95E-10	6.14E-04	2.38E-08	2.39E-08
SD01-8	95	844	4.23E-04	2.32E-05	7.00E-06	2.27E-04	1.14E-05	1.21E-09	6.56E-04	3.14E-08	3.15E-08
SD01-8	96	844	3.17E-04	1.97E-05	5.60E-06	1.89E-04	8.14E-06	1.04E-09	4.48E-04	2.63E-08	2.64E-08
SD01-8	97	844	3.71E-04	2.60E-05	7.01E-06	2.45E-04	9.08E-06	1.37E-09	4.80E-04	3.42E-08	3.44E-08
SD01-8	98	844	2.79E-04	2.20E-05	5.62E-06	2.04E-04	6.52E-06	1.15E-09	3.31E-04	2.82E-08	2.83E-08
SD01-8	99	844	3.21E-04	2.85E-05	6.94E-06	2.59E-04	7.17E-06	1.47E-09	3.49E-04	3.57E-08	3.59E-08

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD01-8	100	844	2.39E-04	2.38E-05	5.55E-06	2.12E-04	5.11E-06	1.21E-09	2.38E-04	2.92E-08	2.93E-08
SD01-8	101	844	2.83E-04	3.17E-05	6.75E-06	2.75E-04	5.77E-06	1.44E-09	2.58E-04	3.63E-08	3.65E-08
SD01-8	102	844	2.07E-04	2.61E-05	5.33E-06	2.21E-04	4.07E-06	1.17E-09	1.74E-04	2.91E-08	2.92E-08
SD01-8	103	844	2.48E-04	3.49E-05	6.50E-06	2.88E-04	4.67E-06	1.37E-09	1.91E-04	3.62E-08	3.64E-08
SD01-8	104	844	1.84E-04	2.90E-05	4.88E-06	2.33E-04	3.33E-06	9.71E-10	1.30E-04	2.78E-08	2.79E-08
SD01-8	105	844	2.11E-04	3.72E-05	5.82E-06	2.90E-04	3.71E-06	1.11E-09	1.38E-04	3.36E-08	3.37E-08
SD01-8	106	844	1.56E-04	3.05E-05	4.76E-06	2.32E-04	2.67E-06	9.49E-10	9.37E-05	2.74E-08	2.76E-08
SD01-8	107	844	1.84E-04	3.98E-05	5.97E-06	2.96E-04	3.09E-06	1.17E-09	1.03E-04	3.46E-08	3.48E-08
SD01-8	108	844	1.35E-04	3.20E-05	4.76E-06	2.33E-04	2.23E-06	9.52E-10	6.94E-05	2.76E-08	2.78E-08
SD01-8	109	844	1.58E-04	4.09E-05	6.11E-06	2.93E-04	2.58E-06	1.25E-09	7.54E-05	3.54E-08	3.56E-08
SD01-8	110	844	1.17E-04	3.33E-05	4.91E-06	2.34E-04	1.92E-06	1.02E-09	5.21E-05	2.85E-08	2.87E-08
SD01-8	111	844	1.36E-04	4.23E-05	6.24E-06	2.92E-04	2.26E-06	1.32E-09	5.64E-05	3.61E-08	3.63E-08
SD01-8	112	844	1.03E-04	3.48E-05	5.04E-06	2.36E-04	1.74E-06	1.06E-09	3.97E-05	2.92E-08	2.93E-08
SD01-8	113	844	1.39E-04	4.50E-05	6.31E-06	2.99E-04	2.10E-06	1.19E-09	4.42E-05	3.54E-08	3.56E-08
SD01-8	114	844	1.01E-04	3.55E-05	5.05E-06	2.30E-04	1.56E-06	8.71E-10	3.01E-05	2.68E-08	2.70E-08
SD01-8	115	844	1.18E-04	4.52E-05	6.73E-06	2.87E-04	1.91E-06	1.17E-09	3.33E-05	3.45E-08	3.47E-08
SD01-8	116	844	8.87E-05	3.72E-05	5.56E-06	2.31E-04	1.51E-06	9.27E-10	2.41E-05	2.78E-08	2.79E-08
SD01-8	117	844	1.03E-04	4.71E-05	7.57E-06	2.86E-04	1.79E-06	1.06E-09	2.68E-05	3.35E-08	3.37E-08
SD01-8	118	844	7.48E-05	3.77E-05	6.36E-06	2.23E-04	1.34E-06	7.94E-10	1.90E-05	2.59E-08	2.60E-08
SD01-8	119	844	8.67E-05	4.76E-05	8.03E-06	2.75E-04	1.61E-06	1.04E-09	2.15E-05	3.28E-08	3.30E-08
SD01-8	120	844	6.42E-05	3.85E-05	6.45E-06	2.17E-04	1.24E-06	8.54E-10	1.57E-05	2.65E-08	2.66E-08
SD01-8	121	844	6.84E-05	4.49E-05	6.84E-06	2.37E-04	3.57E-06	8.99E-08	3.70E-05	3.65E-08	2.79E-08
SD01-8	122	844	2.78E-05	1.95E-05	2.72E-06	9.54E-05	2.27E-06	7.56E-08	2.38E-05	1.83E-08	1.10E-08
SD01-8	123	844	3.28E-05	2.42E-05	3.40E-06	1.18E-04	2.55E-06	7.90E-08	2.55E-05	2.11E-08	1.35E-08
SD01-8	124	844	3.04E-05	2.39E-05	3.40E-06	1.15E-04	2.28E-06	6.47E-08	2.16E-05	1.95E-08	1.32E-08
SD03	1	820	1.18E-04	5.15E-05	1.15E-06	4.90E-05	4.88E-05	7.98E-07	1.22E-05	1.58E-11	1.58E-11
SD03	2	821	9.81E-05	4.27E-05	9.55E-07	4.06E-05	4.05E-05	6.62E-07	1.01E-05	1.31E-11	1.31E-11

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD03	3	824	5.32E-05	2.32E-05	5.18E-07	2.20E-05	2.20E-05	3.59E-07	5.47E-06	7.09E-12	7.10E-12
SD03	4	842	1.24E-03	1.05E-03	1.33E-04	9.44E-04	9.45E-04	1.17E-06	1.02E-04	2.34E-11	2.34E-11
SD03	5	842	5.95E-03	4.87E-03	1.60E-04	4.11E-03	4.12E-03	2.38E-05	1.07E-03	4.21E-10	4.21E-10
SD03	6	842	1.39E-02	8.95E-03	1.87E-04	8.08E-03	8.12E-03	1.03E-04	2.12E-03	1.75E-09	1.75E-09
SD03	7	842	1.28E-02	4.58E-03	7.73E-05	4.36E-03	4.36E-03	8.05E-05	1.11E-03	1.46E-09	1.46E-09
SD03	8	842	1.95E-02	3.90E-03	6.02E-05	4.08E-03	4.00E-03	8.46E-05	9.61E-04	1.86E-09	1.86E-09
SD03	9	842	2.33E-02	4.33E-03	5.47E-05	4.63E-03	4.57E-03	1.19E-04	1.09E-03	2.61E-09	2.62E-09
SD03	10	820	1.72E-04	2.26E-05	3.10E-07	2.44E-05	2.44E-05	9.92E-07	5.65E-06	8.95E-11	2.32E-11
SD03	11	821	1.42E-04	1.88E-05	2.57E-07	2.02E-05	2.02E-05	8.23E-07	4.68E-06	7.36E-11	1.92E-11
SD03	12	824	7.72E-05	1.02E-05	1.40E-07	1.10E-05	1.10E-05	4.47E-07	2.54E-06	3.97E-11	1.04E-11
SD03	13	842	1.71E-02	2.48E-03	2.98E-05	2.60E-03	2.58E-03	7.17E-05	6.26E-04	1.60E-09	1.61E-09
SD03	14	842	2.28E-02	2.72E-03	3.32E-05	2.87E-03	2.86E-03	8.26E-05	6.87E-04	2.00E-09	2.00E-09
SD03	15	842	1.70E-02	1.98E-03	2.50E-05	2.13E-03	2.13E-03	7.15E-05	5.00E-04	1.72E-09	1.72E-09
SD03	16	842	2.31E-02	2.79E-03	4.35E-05	3.13E-03	3.14E-03	1.59E-04	7.07E-04	3.34E-09	3.34E-09
SD03	17	842	2.23E-02	2.48E-03	3.80E-05	2.78E-03	2.79E-03	1.41E-04	6.28E-04	2.98E-09	2.98E-09
SD03	18	842	1.83E-02	3.25E-03	3.92E-05	1.80E-03	1.74E-03	8.19E-05	3.93E-04	4.27E-07	1.01E-08
SD03	19	820	1.85E-04	1.63E-05	2.88E-07	1.27E-05	1.22E-05	3.72E-07	1.97E-06	2.31E-09	8.78E-11
SD03	20	821	1.53E-04	1.36E-05	2.39E-07	1.06E-05	1.01E-05	3.09E-07	1.63E-06	1.92E-09	7.28E-11
SD03	21	824	8.31E-05	7.36E-06	1.30E-07	5.73E-06	5.48E-06	1.68E-07	8.86E-07	1.04E-09	3.95E-11
SD03	22	842	2.84E-02	5.23E-03	7.96E-05	2.96E-03	2.51E-03	1.00E-04	5.05E-04	8.90E-07	2.72E-08
SD03	23	842	2.57E-02	3.22E-03	5.45E-05	2.56E-03	2.55E-03	7.30E-05	3.70E-04	4.88E-07	1.70E-08
SD03	24	842	2.26E-02	1.84E-03	3.97E-05	1.54E-03	1.50E-03	4.16E-05	2.12E-04	2.77E-07	1.13E-08
SD03	25	842	2.19E-02	1.17E-03	2.54E-05	1.04E-03	9.47E-04	2.60E-05	1.35E-04	1.77E-07	9.42E-09
SD03	26	842	1.60E-02	6.73E-04	1.41E-05	6.26E-04	5.24E-04	1.42E-05	8.24E-05	1.00E-07	6.75E-09
SD03	27	842	2.08E-02	8.18E-04	1.49E-05	7.36E-04	5.55E-04	1.47E-05	1.17E-04	1.09E-07	9.13E-09
SD03	28	820	1.48E-04	6.94E-06	5.88E-08	3.97E-06	2.27E-06	5.53E-08	1.50E-06	4.71E-10	6.57E-11
SD03	29	821	1.23E-04	5.76E-06	4.88E-08	3.29E-06	1.88E-06	4.59E-08	1.24E-06	3.91E-10	5.45E-11

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD03	30	824	6.68E-05	3.12E-06	2.65E-08	1.79E-06	1.02E-06	2.49E-08	6.74E-07	2.12E-10	2.96E-11
SD03	31	842	1.52E-02	6.10E-04	9.07E-06	5.03E-04	3.40E-04	8.81E-06	1.03E-04	6.84E-08	7.06E-09
SD03	32	842	1.98E-02	9.08E-04	9.89E-06	6.16E-04	3.75E-04	9.42E-06	1.80E-04	7.73E-08	9.58E-09
SD03	33	842	1.92E-02	9.86E-04	7.75E-06	5.54E-04	3.00E-04	7.18E-06	2.18E-04	6.34E-08	9.52E-09
SD03	34	842	1.40E-02	7.79E-04	4.61E-06	3.75E-04	1.83E-04	4.17E-06	1.83E-04	3.95E-08	6.97E-09
SD03	35	842	1.82E-02	1.06E-03	4.85E-06	4.53E-04	2.01E-04	4.27E-06	2.59E-04	4.38E-08	8.99E-09
SD03	36	842	1.33E-02	7.78E-04	2.84E-06	3.06E-04	1.24E-04	2.44E-06	1.95E-04	2.70E-08	6.40E-09
SD03	37	820	1.31E-04	4.86E-06	1.46E-08	2.34E-06	8.05E-07	1.19E-08	1.22E-06	1.62E-10	5.82E-11
SD03	38	821	1.09E-04	4.03E-06	1.21E-08	1.94E-06	6.67E-07	9.88E-09	1.01E-06	1.34E-10	4.82E-11
SD03	39	824	5.91E-05	2.19E-06	6.56E-09	1.05E-06	3.62E-07	5.36E-09	5.48E-07	7.29E-11	2.62E-11
SD03	40	842	1.73E-02	9.71E-04	2.94E-06	3.70E-04	1.38E-04	2.49E-06	2.47E-04	2.94E-08	8.10E-09
SD03	41	842	1.68E-02	8.00E-04	2.21E-06	3.32E-04	1.16E-04	1.83E-06	2.03E-04	2.37E-08	7.79E-09
SD03	42	842	1.23E-02	4.59E-04	1.31E-06	2.29E-04	7.59E-05	1.06E-06	1.15E-04	1.51E-08	5.73E-09
SD03	43	842	1.59E-02	4.89E-04	1.42E-06	2.86E-04	9.11E-05	1.11E-06	1.21E-04	1.76E-08	7.62E-09
SD03	44	842	1.16E-02	3.00E-04	8.80E-07	2.03E-04	6.34E-05	6.70E-07	7.28E-05	1.19E-08	5.80E-09
SD03	45	842	1.51E-02	3.35E-04	1.00E-06	2.64E-04	8.16E-05	7.33E-07	7.95E-05	1.48E-08	8.04E-09
SD03	46	820	1.10E-04	1.73E-06	5.34E-09	2.13E-06	6.17E-07	3.44E-09	3.71E-07	1.02E-10	6.90E-11
SD03	47	821	9.16E-05	1.44E-06	4.43E-09	1.77E-06	5.11E-07	2.86E-09	3.08E-07	8.48E-11	5.72E-11
SD03	48	824	4.97E-05	7.79E-07	2.40E-09	9.59E-07	2.77E-07	1.55E-09	1.67E-07	4.60E-11	3.10E-11
SD03	49	842	1.47E-02	2.82E-04	8.55E-07	2.68E-04	8.07E-05	5.97E-07	6.46E-05	1.41E-08	8.46E-09
SD03	50	842	1.07E-02	1.86E-04	5.70E-07	2.04E-04	6.04E-05	3.81E-07	4.11E-05	1.02E-08	6.58E-09
SD03	51	842	1.39E-02	2.22E-04	6.85E-07	2.81E-04	8.05E-05	4.38E-07	4.72E-05	1.33E-08	9.07E-09
SD03	52	842	1.02E-02	1.50E-04	4.68E-07	2.15E-04	6.06E-05	2.85E-07	3.07E-05	9.82E-09	7.01E-09
SD03	53	842	1.32E-02	1.82E-04	5.75E-07	2.91E-04	8.16E-05	3.33E-07	3.57E-05	1.30E-08	9.63E-09
SD03	54	842	1.28E-02	1.65E-04	5.28E-07	2.96E-04	8.30E-05	2.88E-07	3.07E-05	1.29E-08	9.95E-09
SD03	55	820	8.86E-05	9.52E-07	3.24E-09	2.17E-06	6.41E-07	1.47E-09	1.55E-07	9.36E-11	7.75E-11
SD03	56	821	7.34E-05	7.90E-07	2.69E-09	1.80E-06	5.31E-07	1.22E-09	1.29E-07	7.76E-11	6.43E-11

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD03	57	824	3.98E-05	4.28E-07	1.46E-09	9.78E-07	2.88E-07	6.61E-10	6.99E-08	4.21E-11	3.49E-11
SD03	58	842	9.35E-03	1.15E-04	3.71E-07	2.24E-04	6.33E-05	1.91E-07	2.03E-05	9.66E-09	7.66E-09
SD03	59	842	1.21E-02	1.43E-04	4.66E-07	3.01E-04	8.60E-05	2.25E-07	2.39E-05	1.29E-08	1.04E-08
SD03	60	842	8.85E-03	1.01E-04	3.32E-07	2.26E-04	6.59E-05	1.50E-07	1.58E-05	9.65E-09	8.01E-09
SD03	61	842	1.15E-02	1.22E-04	4.22E-07	3.01E-04	8.98E-05	1.78E-07	1.87E-05	1.29E-08	1.09E-08
SD03	62	842	1.11E-02	1.08E-04	4.03E-07	2.98E-04	9.18E-05	1.56E-07	1.63E-05	1.29E-08	1.11E-08
SD03	63	842	8.13E-03	7.30E-05	2.91E-07	2.21E-04	7.00E-05	1.04E-07	1.09E-05	9.65E-09	8.41E-09
SD03	64	842	1.00E-02	8.40E-05	3.57E-07	2.76E-04	8.99E-05	1.19E-07	1.23E-05	1.22E-08	1.07E-08
SD05	1	9609	5.14E-02	4.79E-02	5.17E-03	4.13E-02	4.14E-02	5.95E-05	5.88E-03	1.20E-09	1.20E-09
SD05	2	9599	3.23E-03	2.98E-03	4.22E-05	2.40E-03	2.47E-03	1.52E-05	7.31E-04	2.56E-10	2.56E-10
SD05	3	9609	2.50E-01	2.29E-01	2.98E-03	1.99E-01	2.02E-01	2.10E-03	5.67E-02	3.49E-08	3.49E-08
SD05	4	9599	4.71E-04	4.16E-04	4.02E-06	4.13E-04	4.13E-04	9.37E-06	1.06E-04	1.59E-10	1.59E-10
SD05	5	9609	1.63E-01	1.44E-01	1.33E-03	1.40E-01	1.41E-01	3.17E-03	3.70E-02	5.37E-08	5.38E-08
SD05	6	9599	2.04E-03	1.55E-03	1.75E-05	1.63E-03	1.59E-03	5.30E-05	4.02E-04	1.09E-09	1.09E-09
SD05	7	9609	1.18E-01	8.75E-02	1.01E-03	9.45E-02	9.12E-02	3.36E-03	2.28E-02	6.92E-08	6.92E-08
SD05	8	9599	5.48E-05	3.91E-05	5.05E-07	4.41E-05	4.03E-05	1.88E-06	1.02E-05	3.87E-11	3.88E-11
SD05	9	9609	1.27E-01	9.08E-02	1.10E-03	1.02E-01	8.93E-02	4.32E-03	2.37E-02	8.83E-08	8.83E-08
SD05	10	9609	4.82E-02	3.58E-02	3.17E-04	3.99E-02	3.28E-02	1.36E-03	9.24E-03	2.73E-08	2.73E-08
SD05	11	9609	4.34E-02	3.61E-02	2.33E-04	3.76E-02	3.61E-02	9.73E-04	9.32E-03	2.09E-08	2.09E-08
SD05	12	9609	2.34E-02	2.08E-02	1.43E-04	2.17E-02	2.16E-02	6.04E-04	5.35E-03	1.34E-08	1.34E-08
SD05	13	9599	1.51E-03	1.06E-03	1.19E-05	1.38E-03	1.39E-03	4.33E-05	2.68E-04	9.63E-10	9.99E-10
SD05	14	9609	4.02E-02	3.06E-02	2.97E-04	3.66E-02	3.69E-02	1.10E-03	7.78E-03	2.52E-08	2.55E-08
SD05	15	9609	1.92E-02	1.65E-02	1.19E-04	1.78E-02	1.80E-02	4.28E-04	4.23E-03	1.07E-08	1.07E-08
SD05	16	9609	4.45E-02	3.02E-02	1.63E-03	1.98E-02	1.67E-02	2.59E-04	3.40E-03	4.37E-05	8.16E-07
SD05	17	9609	4.86E-02	3.34E-02	3.98E-03	2.51E-02	1.00E-02	1.25E-04	2.05E-03	8.03E-05	1.88E-06
SD05	18	9609	7.28E-03	5.99E-03	7.56E-04	7.62E-03	1.97E-03	1.61E-05	3.89E-04	1.41E-05	4.43E-07
SD05	19	9609	6.03E-03	7.01E-03	6.85E-04	1.46E-02	3.91E-03	1.22E-05	4.52E-04	1.11E-05	5.15E-07

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD05	20	9609	1.76E-03	3.03E-03	4.63E-04	1.23E-02	1.30E-02	3.30E-06	2.08E-04	3.34E-06	3.35E-07
SD05	21	9609	5.34E-04	1.29E-03	5.69E-04	7.08E-03	5.02E-03	1.07E-06	1.19E-04	1.36E-06	2.80E-07
SD05	22	9609	1.76E-04	8.07E-04	3.43E-04	5.26E-03	2.01E-03	4.32E-07	9.40E-05	8.10E-07	2.58E-07
SD05	23	9609	3.86E-05	3.47E-04	6.49E-05	2.27E-03	6.78E-04	1.14E-07	4.66E-05	3.29E-07	1.24E-07
SD05	24	9609	3.59E-05	7.05E-04	6.22E-05	4.03E-03	1.16E-03	1.15E-07	1.12E-04	5.85E-07	2.43E-07
SD05	25	9609	1.17E-05	1.01E-03	2.99E-05	3.53E-03	1.09E-03	4.28E-08	2.07E-04	5.26E-07	2.33E-07
SD05	26	9609	3.81E-06	1.70E-03	1.80E-05	2.96E-03	1.01E-03	2.05E-08	4.10E-04	4.32E-07	2.11E-07
SD05	27	9609	1.25E-06	2.84E-03	1.19E-05	2.53E-03	9.67E-04	1.68E-08	7.34E-04	3.48E-07	1.94E-07
SD05	28	9609	4.17E-07	1.97E-03	4.09E-06	1.18E-03	4.90E-04	9.31E-09	5.19E-04	1.47E-07	9.52E-08
SD05	29	9609	5.96E-07	5.15E-03	5.13E-06	2.14E-03	9.49E-04	3.35E-08	1.38E-03	2.43E-07	1.85E-07
SD05	30	9609	6.56E-07	6.69E-03	3.24E-06	1.81E-03	8.76E-04	5.59E-08	1.81E-03	2.06E-07	1.77E-07
SD05	31	9609	7.75E-07	6.36E-03	2.44E-06	1.55E-03	8.03E-04	7.64E-08	1.72E-03	1.87E-07	1.69E-07
SD05	32	9609	8.94E-07	2.01E-03	2.12E-06	1.41E-03	7.79E-04	8.01E-08	5.08E-04	1.79E-07	1.66E-07
SD05	33	9609	5.36E-07	4.21E-04	1.03E-06	7.00E-04	3.98E-04	4.10E-08	8.52E-05	8.93E-08	8.35E-08
SD05	34	9609	1.25E-06	5.76E-04	1.99E-06	1.41E-03	8.01E-04	8.20E-08	7.39E-05	1.77E-07	1.66E-07
SD05	35	9609	1.37E-06	5.74E-04	1.82E-06	1.44E-03	7.61E-04	8.38E-08	2.95E-05	1.70E-07	1.61E-07
SD05	36	9609	1.67E-06	7.73E-04	1.61E-06	1.57E-03	6.98E-04	8.01E-08	1.90E-05	1.60E-07	1.52E-07
SD05	37	9609	1.79E-06	6.98E-04	1.40E-06	1.82E-03	6.18E-04	8.01E-08	2.11E-05	1.48E-07	1.42E-07
SD05	38	9609	1.01E-06	2.00E-04	6.54E-07	1.02E-03	2.95E-04	4.10E-08	9.00E-06	7.10E-08	6.81E-08
SD05	39	9609	1.97E-06	2.47E-04	1.28E-06	1.27E-03	5.88E-04	8.20E-08	1.37E-05	1.39E-07	1.33E-07
SD05	40	9609	2.27E-06	1.81E-04	1.25E-06	8.03E-04	5.94E-04	8.01E-08	1.05E-05	1.36E-07	1.31E-07
SD05	41	9609	2.21E-06	1.81E-04	1.22E-06	6.86E-04	6.05E-04	7.64E-08	9.28E-06	1.33E-07	1.28E-07
SD05	42	9609	2.50E-06	1.99E-04	1.20E-06	6.55E-04	6.22E-04	7.64E-08	8.61E-06	1.30E-07	1.26E-07
SD05	43	9609	1.13E-06	1.09E-04	5.89E-07	3.24E-04	3.19E-04	3.73E-08	4.13E-06	6.40E-08	6.19E-08
SD05	44	9609	2.44E-06	2.42E-04	1.16E-06	6.47E-04	6.59E-04	7.26E-08	7.99E-06	1.26E-07	1.22E-07
SD05	45	9609	2.56E-06	2.77E-04	1.14E-06	6.54E-04	6.97E-04	7.08E-08	7.64E-06	1.22E-07	1.19E-07
SD05	46	9609	2.32E-06	3.19E-04	1.13E-06	6.67E-04	7.49E-04	6.89E-08	7.36E-06	1.19E-07	1.16E-07

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD05	47	9609	2.50E-06	3.66E-04	1.13E-06	6.90E-04	8.17E-04	6.71E-08	7.21E-06	1.16E-07	1.13E-07
SD05	48	9609	1.07E-06	2.03E-04	5.66E-07	3.55E-04	4.41E-04	3.17E-08	3.55E-06	5.67E-08	5.54E-08
SD05	49	9609	2.27E-06	4.47E-04	1.15E-06	7.37E-04	9.60E-04	6.33E-08	7.11E-06	1.11E-07	1.09E-07
SD05	50	9609	2.21E-06	5.07E-04	1.16E-06	7.75E-04	9.60E-04	5.96E-08	7.06E-06	1.07E-07	1.05E-07
SD05	51	9609	2.15E-06	5.71E-04	1.19E-06	8.22E-04	6.76E-04	5.59E-08	6.91E-06	1.04E-07	1.02E-07
SD05	52	9609	2.03E-06	6.41E-04	1.23E-06	8.80E-04	5.78E-04	5.77E-08	6.53E-06	1.00E-07	9.86E-08
SD05	53	9609	1.01E-06	3.46E-04	6.28E-07	4.66E-04	2.67E-04	2.61E-08	3.08E-06	4.90E-08	4.82E-08
SD05	54	9609	1.91E-06	3.88E-04	1.28E-06	9.86E-04	5.17E-04	5.03E-08	5.98E-06	9.55E-08	9.41E-08
SD05	55	9609	1.79E-06	1.62E-04	1.31E-06	1.07E-03	5.01E-04	4.84E-08	4.72E-06	9.22E-08	9.10E-08
SD05	56	9609	1.67E-06	1.07E-04	1.34E-06	1.15E-03	4.90E-04	4.66E-08	1.27E-06	8.91E-08	8.80E-08
SD05	57	9609	1.55E-06	1.02E-04	1.38E-06	1.27E-03	4.90E-04	4.28E-08	3.58E-07	8.76E-08	8.66E-08
SD05	58	9609	7.75E-07	5.22E-05	6.97E-07	6.69E-04	2.41E-04	2.24E-08	7.45E-08	4.26E-08	4.22E-08
SD05	59	9609	1.49E-06	8.92E-05	1.40E-06	1.13E-03	4.77E-04	3.91E-08	1.19E-07	8.31E-08	8.23E-08
SD05	60	9609	1.31E-06	4.11E-05	1.42E-06	4.49E-04	4.72E-04	3.91E-08	8.94E-08	8.07E-08	7.99E-08
SD05	61	9609	1.25E-06	2.89E-05	1.44E-06	2.66E-04	4.69E-04	3.54E-08	1.19E-07	7.85E-08	7.78E-08
SD05	62	9609	1.13E-06	2.64E-05	2.78E-06	2.22E-04	4.66E-04	3.54E-08	1.19E-07	7.65E-08	7.59E-08
SD05	63	9609	6.56E-07	1.32E-05	7.45E-06	1.05E-04	2.33E-04	1.49E-08	5.96E-08	3.76E-08	3.73E-08
SD05	64	9609	1.01E-06	2.65E-05	2.29E-05	2.03E-04	4.64E-04	3.17E-08	1.19E-07	7.39E-08	7.33E-08
SD05	65	9609	1.07E-06	2.69E-05	2.79E-05	1.96E-04	4.64E-04	2.98E-08	1.34E-07	7.22E-08	7.17E-08
SD05	66	9609	1.25E-06	2.77E-05	3.15E-05	1.92E-04	4.68E-04	2.79E-08	1.34E-07	7.12E-08	7.07E-08
SD05	67	9609	4.47E-06	2.15E-05	3.50E-05	1.75E-04	4.65E-04	6.89E-08	6.56E-07	6.95E-08	6.91E-08
SD05	68	9609	1.01E-06	8.23E-06	1.65E-05	8.03E-05	2.26E-04	2.61E-08	1.94E-07	3.35E-08	3.33E-08
SD05	69	9609	1.01E-06	1.77E-05	3.39E-05	1.58E-04	4.53E-04	2.61E-08	2.24E-07	6.58E-08	6.54E-08
SD05	70	9609	4.17E-07	2.00E-05	3.59E-05	1.57E-04	4.55E-04	1.68E-08	1.79E-07	6.45E-08	6.42E-08
SD05	71	9609	2.38E-07	2.15E-05	3.82E-05	1.55E-04	4.58E-04	1.30E-08	1.34E-07	6.33E-08	6.29E-08
SD05	72	9609	1.19E-07	2.24E-05	3.45E-05	1.52E-04	4.61E-04	1.30E-08	1.79E-07	6.20E-08	6.17E-08
SD05	73	9609	0.00E+00	1.15E-05	1.54E-05	7.50E-05	2.31E-04	5.59E-09	1.04E-07	3.05E-08	3.04E-08

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD05	74	9609	0.00E+00	1.65E-05	2.02E-05	1.04E-04	3.25E-04	7.45E-09	1.34E-07	4.23E-08	4.21E-08
SD07	1	9599	1.58E-02	1.17E-03	3.81E-05	1.10E-03	8.67E-04	3.25E-06	2.37E-04	6.73E-11	6.73E-11
SD07	2	9609	9.78E-02	7.09E-03	2.24E-04	7.36E-03	5.45E-03	2.18E-05	1.44E-03	4.42E-10	4.42E-10
SD07	3	9599	4.86E-02	2.71E-03	3.20E-05	5.58E-03	2.73E-03	2.60E-05	5.83E-04	5.10E-10	5.11E-10
SD07	4	9609	2.62E-01	1.48E-02	1.85E-04	2.96E-02	1.47E-02	1.34E-04	3.17E-03	2.63E-09	2.63E-09
SD07	5	9599	4.73E-03	2.55E-04	2.70E-06	6.09E-04	3.12E-04	4.44E-06	5.48E-05	9.33E-11	9.35E-11
SD07	6	9609	1.21E-01	6.68E-03	7.20E-05	1.57E-02	8.19E-03	1.25E-04	1.44E-03	2.62E-09	2.63E-09
SD07	7	9599	1.05E-02	9.17E-04	1.07E-05	1.47E-03	1.55E-03	3.34E-05	2.22E-04	6.26E-10	6.29E-10
SD07	8	9609	7.68E-02	8.35E-03	7.31E-05	1.36E-02	1.16E-02	2.13E-04	2.00E-03	4.35E-09	4.38E-09
SD07	9	9599	4.50E-03	3.61E-04	4.60E-06	5.76E-04	6.36E-04	1.45E-05	8.75E-05	2.70E-10	2.71E-10
SD07	10	9609	1.10E-01	8.23E-03	1.01E-04	1.36E-02	1.42E-02	3.22E-04	1.99E-03	6.09E-09	6.13E-09
SD07	11	9599	2.00E-02	3.68E-03	9.13E-05	3.79E-03	3.00E-03	8.70E-06	2.10E-04	2.98E-06	4.49E-08
SD07	12	9609	1.56E-01	7.35E-02	5.19E-03	4.40E-02	2.06E-02	1.13E-04	1.70E-03	1.21E-04	2.33E-06
SD07	13	9599	5.94E-04	3.53E-04	7.50E-05	5.20E-04	1.28E-04	5.54E-07	8.95E-06	2.02E-06	4.24E-08
SD07	14	9609	5.24E-02	3.35E-02	6.30E-03	6.44E-02	1.49E-02	7.02E-05	1.07E-03	1.72E-04	3.97E-06
SD07	15	9609	1.41E-02	2.12E-02	2.17E-03	3.48E-02	8.96E-03	1.86E-05	3.57E-03	4.44E-05	1.64E-06
SD07	16	9609	3.77E-03	2.72E-02	7.07E-04	1.80E-02	6.53E-03	3.95E-06	6.80E-03	1.32E-05	9.32E-07
SD07	17	9609	1.01E-03	7.09E-03	2.17E-04	1.08E-02	5.22E-03	8.81E-07	1.64E-03	4.83E-06	6.11E-07
SD07	18	9609	2.73E-04	2.29E-03	8.62E-05	8.84E-03	4.42E-03	2.34E-07	4.06E-04	2.12E-06	4.35E-07
SD07	19	9609	7.39E-05	1.29E-03	4.37E-05	1.04E-02	4.68E-03	9.34E-08	9.21E-05	1.18E-06	3.81E-07
SD07	20	9609	2.02E-05	1.15E-03	2.22E-05	9.51E-03	5.08E-03	6.09E-08	2.19E-05	6.46E-07	3.38E-07
SD07	21	9609	6.02E-06	1.03E-03	1.69E-05	8.89E-03	5.72E-03	5.16E-08	6.14E-06	4.53E-07	3.11E-07
SD07	22	9609	1.97E-06	9.46E-04	1.71E-05	1.01E-02	6.57E-03	4.80E-08	2.64E-06	3.72E-07	2.90E-07
SD07	23	9609	8.94E-07	9.50E-04	2.27E-05	1.05E-02	6.29E-03	4.60E-08	2.00E-06	3.24E-07	2.68E-07
SD07	24	9609	5.36E-07	6.54E-04	2.43E-05	5.69E-03	4.34E-03	4.37E-08	2.01E-06	2.86E-07	2.46E-07
SD07	25	9609	5.36E-07	5.46E-04	2.54E-05	3.26E-03	3.85E-03	4.17E-08	2.22E-06	2.57E-07	2.26E-07
SD07	26	9609	4.77E-07	4.99E-04	2.92E-05	2.86E-03	3.74E-03	3.98E-08	2.52E-06	2.34E-07	2.10E-07

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD07	27	9609	5.36E-07	4.00E-04	3.13E-05	2.93E-03	3.75E-03	3.80E-08	2.62E-06	2.16E-07	1.96E-07
SD07	28	9609	5.36E-07	4.02E-04	4.15E-05	2.80E-03	3.88E-03	3.69E-08	2.86E-06	1.99E-07	1.83E-07
SD07	29	9609	5.36E-07	4.84E-04	4.81E-05	3.18E-03	4.12E-03	3.55E-08	3.56E-06	1.85E-07	1.72E-07
SD07	30	9609	5.96E-07	5.32E-04	2.26E-05	2.81E-03	4.47E-03	3.48E-08	4.46E-06	1.72E-07	1.61E-07
SD07	31	9609	5.36E-07	5.85E-04	1.63E-05	2.27E-03	4.70E-03	3.38E-08	5.48E-06	1.60E-07	1.51E-07
SD07	32	9609	4.77E-07	4.67E-04	1.64E-05	1.80E-03	4.34E-03	3.29E-08	6.64E-06	1.51E-07	1.43E-07
SD07	33	9609	5.96E-07	2.89E-04	1.64E-05	1.75E-03	4.04E-03	3.20E-08	8.00E-06	1.43E-07	1.36E-07
SD07	34	9609	4.77E-07	2.53E-04	1.69E-05	1.52E-03	4.12E-03	3.13E-08	9.56E-06	1.37E-07	1.30E-07
SD07	35	9609	5.36E-07	2.88E-04	2.24E-05	1.66E-03	4.36E-03	3.05E-08	1.14E-05	1.31E-07	1.25E-07
SD07	36	9609	4.77E-07	3.21E-04	3.88E-05	1.93E-03	4.41E-03	2.93E-08	1.20E-05	1.26E-07	1.21E-07
SD07	37	9609	5.36E-07	2.84E-04	4.27E-05	2.23E-03	3.83E-03	2.89E-08	1.06E-05	1.21E-07	1.16E-07
SD07	38	9609	4.77E-07	3.04E-04	5.28E-05	3.02E-03	3.93E-03	2.86E-08	1.16E-05	1.17E-07	1.12E-07
SD07	39	9609	4.77E-07	4.22E-04	6.76E-05	4.87E-03	4.26E-03	2.92E-08	1.35E-05	1.13E-07	1.09E-07
SD07	40	9609	4.17E-07	4.53E-04	8.27E-05	5.28E-03	4.61E-03	2.96E-08	1.58E-05	1.09E-07	1.05E-07
SD07	41	9609	4.17E-07	2.26E-04	8.94E-05	1.98E-03	4.57E-03	2.98E-08	1.84E-05	1.05E-07	1.02E-07
SD07	42	9609	3.58E-07	1.37E-04	9.47E-05	6.04E-04	3.08E-03	2.96E-08	2.12E-05	1.02E-07	9.92E-08
SD07	43	9609	4.17E-07	1.25E-04	8.99E-05	2.96E-04	2.48E-03	2.95E-08	2.40E-05	9.87E-08	9.63E-08
SD07	44	9609	3.58E-07	1.30E-04	5.01E-05	2.21E-04	2.38E-03	2.89E-08	2.70E-05	9.57E-08	9.36E-08
SD07	45	9609	4.17E-07	1.39E-04	3.30E-05	1.97E-04	2.42E-03	2.89E-08	3.00E-05	9.29E-08	9.10E-08
SD07	46	9609	4.17E-07	1.48E-04	3.02E-05	1.85E-04	2.49E-03	2.86E-08	3.31E-05	9.01E-08	8.86E-08
SD07	47	9609	2.98E-07	1.58E-04	2.99E-05	1.75E-04	2.58E-03	2.86E-08	3.62E-05	8.76E-08	8.62E-08
SD07	48	9609	4.17E-07	1.87E-04	2.68E-05	1.85E-04	2.95E-03	3.15E-08	4.38E-05	9.44E-08	9.31E-08
SD07	49	9609	3.58E-07	1.99E-04	1.33E-05	1.74E-04	3.02E-03	3.15E-08	4.73E-05	9.16E-08	9.05E-08
SD07	50	9609	1.79E-07	1.03E-04	5.42E-06	8.31E-05	1.55E-03	1.57E-08	2.48E-05	4.47E-08	4.43E-08
SD07	51	9609	4.17E-07	2.10E-04	1.01E-05	1.59E-04	3.13E-03	3.14E-08	5.19E-05	8.76E-08	8.68E-08
SD07	52	9609	3.58E-07	2.17E-04	9.71E-06	1.50E-04	3.02E-03	3.14E-08	5.50E-05	8.50E-08	8.44E-08
SD07	53	9609	3.58E-07	2.26E-04	9.99E-06	1.42E-04	2.94E-03	3.15E-08	5.78E-05	8.27E-08	8.22E-08

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD07	54	9609	2.98E-07	2.35E-04	1.05E-05	1.34E-04	2.94E-03	3.17E-08	6.07E-05	8.04E-08	8.02E-08
SD07	55	9609	1.79E-07	1.21E-04	5.48E-06	6.46E-05	1.50E-03	1.57E-08	3.14E-05	3.95E-08	3.94E-08
SD07	56	9609	3.58E-07	2.43E-04	1.15E-05	1.25E-04	3.08E-03	3.18E-08	6.33E-05	7.76E-08	7.74E-08
SD07	57	9609	3.58E-07	2.43E-04	1.21E-05	1.17E-04	3.14E-03	3.15E-08	6.34E-05	7.57E-08	7.57E-08
SD07	58	9609	2.98E-07	2.46E-04	1.21E-05	1.09E-04	3.23E-03	3.19E-08	6.47E-05	7.42E-08	7.43E-08
SD07	59	9609	3.58E-07	2.51E-04	1.17E-05	1.01E-04	3.34E-03	3.19E-08	6.62E-05	7.27E-08	7.29E-08
SD07	60	9609	2.38E-07	1.27E-04	5.18E-06	4.77E-05	1.73E-03	1.59E-08	3.35E-05	3.59E-08	3.60E-08
SD07	61	9609	4.17E-07	2.55E-04	1.00E-05	8.95E-05	3.61E-03	3.21E-08	6.79E-05	7.11E-08	7.14E-08
SD07	62	9609	4.77E-07	2.56E-04	9.71E-06	8.14E-05	3.84E-03	3.22E-08	6.85E-05	7.08E-08	7.06E-08
SD07	63	9609	2.98E-07	2.55E-04	9.62E-06	7.44E-05	4.13E-03	3.26E-08	6.87E-05	7.12E-08	7.09E-08
SD07	64	9609	3.58E-07	2.55E-04	1.02E-05	6.82E-05	4.48E-03	3.25E-08	6.88E-05	7.28E-08	7.25E-08
SD07	65	9609	1.79E-07	1.27E-04	5.43E-06	3.17E-05	2.40E-03	1.64E-08	3.44E-05	3.74E-08	3.74E-08
SD07	66	9609	2.98E-07	2.50E-04	1.16E-05	5.82E-05	5.14E-03	3.25E-08	6.85E-05	7.82E-08	7.82E-08
SD07	67	9609	3.58E-07	2.53E-04	1.42E-05	5.77E-05	5.96E-03	3.21E-08	7.14E-05	8.32E-08	8.33E-08
SD07	68	9609	3.58E-07	2.55E-04	1.60E-05	5.62E-05	6.97E-03	3.27E-08	7.96E-05	8.79E-08	8.82E-08
SD07	69	9609	2.38E-07	2.59E-04	1.74E-05	5.47E-05	8.35E-03	3.32E-08	1.09E-04	9.17E-08	9.20E-08
SD07	70	9609	3.93E-06	1.35E-04	1.03E-05	2.61E-05	4.25E-03	1.76E-08	3.16E-01	5.04E-08	5.05E-08
SD07	71	9609	1.28E-05	4.34E-04	2.08E-05	4.95E-05	3.32E-03	3.45E-08	2.48E-01	1.01E-07	9.95E-08
SD07	72	9609	1.96E-05	6.74E-04	2.62E-05	5.40E-05	1.19E-03	4.12E-08	3.68E-02	1.24E-07	1.20E-07
SD07	73	9609	1.80E-05	8.04E-04	2.76E-05	6.21E-05	9.09E-04	4.46E-08	6.25E-03	1.33E-07	1.26E-07
SD07	74	9609	1.54E-05	8.72E-04	2.79E-05	7.48E-05	9.11E-04	4.56E-08	1.30E-03	1.36E-07	1.28E-07
SD07	75	9609	5.07E-06	4.51E-04	1.23E-05	4.40E-05	4.85E-04	2.17E-08	2.59E-04	6.19E-08	5.83E-08
SD07	76	9609	9.18E-06	8.78E-04	2.56E-05	1.06E-04	1.01E-03	4.44E-08	3.40E-04	1.28E-07	1.20E-07
SD07	77	9609	6.56E-06	8.49E-04	2.47E-05	1.37E-04	1.08E-03	4.44E-08	2.68E-04	1.26E-07	1.19E-07
SD07	78	9609	5.36E-06	8.30E-04	2.36E-05	1.76E-04	1.14E-03	4.33E-08	2.45E-04	1.25E-07	1.18E-07
SD07	79	9609	5.72E-06	8.08E-04	2.75E-05	2.19E-04	8.36E-04	4.55E-08	2.33E-04	1.37E-07	1.31E-07
SD07	80	9609	4.17E-06	7.64E-04	2.70E-05	1.04E-04	1.64E-04	4.46E-08	2.17E-04	1.29E-07	1.23E-07

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD07	81	9609	6.79E-06	8.40E-04	5.56E-05	7.94E-05	3.48E-05	8.87E-08	2.41E-04	2.60E-07	2.50E-07
SD07	82	9609	4.29E-06	2.27E-04	5.22E-05	6.37E-05	5.39E-06	8.82E-08	7.69E-05	2.75E-07	2.65E-07
SD07	83	9609	4.53E-06	2.06E-04	4.98E-05	6.31E-05	4.08E-06	9.44E-08	5.82E-05	2.69E-07	2.59E-07
SD07	84	9609	4.89E-06	2.07E-04	4.82E-05	6.21E-05	4.35E-06	1.02E-07	5.37E-05	2.62E-07	2.52E-07
SD07	85	9609	4.11E-06	2.13E-04	3.78E-05	5.74E-05	5.16E-06	8.57E-08	5.59E-05	2.21E-07	2.11E-07
SD07	86	9609	5.01E-06	2.15E-04	3.79E-05	5.65E-05	5.72E-06	9.97E-08	5.60E-05	2.20E-07	2.10E-07
SD07	87	9609	5.48E-06	1.86E-04	3.85E-05	5.55E-05	6.20E-06	1.11E-07	4.77E-05	2.21E-07	2.11E-07
SD07	88	9609	6.44E-06	1.64E-04	4.00E-05	5.53E-05	6.41E-06	1.26E-07	4.14E-05	2.27E-07	2.17E-07
SD07	89	9609	5.84E-06	1.69E-04	3.46E-05	5.12E-05	6.44E-06	1.09E-07	4.35E-05	2.03E-07	1.93E-07
SD07	90	9609	4.77E-07	1.33E-05	2.83E-06	4.11E-06	5.36E-07	9.43E-09	3.40E-06	1.66E-08	1.57E-08
SD07	91	9609	4.47E-06	1.42E-04	2.77E-05	4.37E-05	5.81E-06	8.91E-08	3.65E-05	1.71E-07	1.61E-07
SD07	92	9609	7.21E-06	8.03E-05	3.82E-05	5.00E-05	6.20E-06	1.69E-07	1.81E-05	2.15E-07	2.04E-07
SD07	93	9609	7.09E-06	7.32E-05	3.72E-05	4.78E-05	5.78E-06	1.84E-07	1.63E-05	2.09E-07	1.99E-07
SD07	94	9609	6.91E-06	7.29E-05	3.69E-05	4.61E-05	5.51E-06	2.08E-07	1.63E-05	2.07E-07	1.97E-07
SD07	95	9609	1.73E-06	1.80E-05	9.03E-06	1.11E-05	1.34E-06	5.51E-08	3.99E-06	5.10E-08	4.83E-08
SD07	96	9609	3.58E-06	4.42E-05	1.93E-05	2.63E-05	3.13E-06	1.20E-07	1.03E-05	1.15E-07	1.08E-07
SD07	97	9609	3.87E-06	4.51E-05	1.96E-05	2.54E-05	2.98E-06	1.55E-07	1.06E-05	1.15E-07	1.09E-07
SD07	98	9609	2.50E-06	3.63E-05	1.39E-05	1.95E-05	2.27E-06	1.21E-07	8.70E-06	8.48E-08	7.97E-08
SD07	99	9609	2.56E-06	2.53E-05	1.55E-05	1.97E-05	2.18E-06	1.56E-07	5.48E-06	9.05E-08	8.54E-08
SD07	100	9609	1.91E-06	1.49E-05	1.28E-05	1.83E-05	2.03E-06	1.30E-07	2.92E-06	7.99E-08	7.49E-08
SD07	101	9609	1.25E-06	1.06E-05	9.98E-06	1.68E-05	2.00E-06	9.66E-08	2.09E-06	6.87E-08	6.37E-08
SD07	102	9609	8.34E-07	7.94E-06	8.55E-06	1.58E-05	1.85E-06	7.11E-08	1.43E-06	6.29E-08	5.79E-08
SD07	103	9609	2.98E-07	3.52E-06	6.13E-06	1.45E-05	1.76E-06	2.41E-08	5.96E-07	5.31E-08	4.82E-08
SD07	104	9609	7.75E-07	8.00E-06	9.21E-06	1.53E-05	1.64E-06	8.00E-08	1.37E-06	6.48E-08	5.98E-08
SD07	105	9609	1.13E-06	7.46E-05	1.07E-05	7.99E-05	8.49E-06	1.88E-07	8.17E-05	7.83E-08	6.34E-08
SD07	106	9609	1.31E-06	1.73E-04	1.03E-05	2.90E-04	8.61E-06	2.01E-07	8.61E-05	7.60E-08	6.08E-08
SD07	107	9609	1.31E-06	3.82E-05	1.03E-05	7.10E-05	3.84E-06	1.34E-07	1.60E-05	6.92E-08	6.24E-08

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD07	108	9609	1.13E-06	1.44E-05	9.32E-06	2.40E-05	2.53E-06	1.16E-07	4.17E-06	6.42E-08	5.89E-08
SD07	109	9609	1.73E-06	1.48E-05	1.19E-05	1.77E-05	2.47E-06	1.81E-07	3.28E-06	7.45E-08	6.93E-08
SD07	110	9609	1.55E-06	1.16E-05	1.04E-05	1.52E-05	1.94E-06	1.51E-07	2.27E-06	6.87E-08	6.37E-08
SD07	111	9609	1.91E-06	1.41E-05	1.21E-05	1.53E-05	1.82E-06	2.10E-07	2.80E-06	7.54E-08	7.02E-08
SD07	112	9609	1.43E-06	1.07E-05	9.68E-06	1.38E-05	1.43E-06	1.59E-07	2.15E-06	6.54E-08	6.03E-08
SD07	113	9609	1.31E-06	8.60E-06	8.54E-06	1.31E-05	1.34E-06	1.39E-07	1.61E-06	6.04E-08	5.54E-08
SD07	114	9609	1.07E-06	7.75E-06	8.02E-06	1.25E-05	1.22E-06	1.32E-07	1.55E-06	5.82E-08	5.31E-08
SD07	115	9609	8.94E-07	6.02E-06	7.13E-06	1.21E-05	1.19E-06	1.03E-07	1.13E-06	5.44E-08	4.94E-08
SD07	116	9609	4.77E-07	3.61E-06	5.54E-06	1.11E-05	1.07E-06	5.62E-08	5.96E-07	4.78E-08	4.27E-08
SD07	117	9609	1.67E-06	1.02E-05	1.02E-05	1.26E-05	1.13E-06	2.29E-07	1.97E-06	6.67E-08	6.15E-08
SD07	118	9609	1.31E-06	7.45E-06	8.10E-06	1.18E-05	1.04E-06	1.78E-07	1.43E-06	5.79E-08	5.28E-08
SD07	119	9609	7.75E-07	4.77E-06	6.04E-06	1.09E-05	9.83E-07	1.08E-07	7.75E-07	4.92E-08	4.42E-08
SD07	120	9609	4.77E-07	3.64E-06	5.25E-06	1.04E-05	9.54E-07	7.45E-08	7.15E-07	4.59E-08	4.08E-08
SD07	121	9609	1.13E-06	6.90E-06	7.00E-06	1.08E-05	8.94E-07	1.78E-07	1.37E-06	5.29E-08	4.77E-08
SD07	122	9609	1.55E-06	9.03E-06	8.81E-06	1.12E-05	8.64E-07	2.62E-07	1.91E-06	6.02E-08	5.50E-08
SD07	123	9609	1.37E-06	7.99E-06	7.85E-06	1.08E-05	8.64E-07	2.51E-07	1.55E-06	5.61E-08	5.10E-08
SD07	124	9609	1.37E-06	8.29E-06	8.18E-06	1.07E-05	8.05E-07	2.74E-07	1.73E-06	5.74E-08	5.23E-08
SD07	125	9609	1.97E-06	1.11E-05	1.02E-05	1.11E-05	8.05E-07	4.02E-07	2.27E-06	6.55E-08	6.04E-08
SD07	126	9609	1.79E-06	1.02E-05	1.01E-05	1.09E-05	7.15E-07	3.82E-07	2.03E-06	6.49E-08	5.99E-08
SD07	127	9609	8.94E-07	5.30E-06	5.94E-06	9.60E-06	7.15E-07	1.81E-07	1.01E-06	4.76E-08	4.27E-08
SD07	128	9609	1.01E-06	6.12E-06	6.07E-06	9.51E-06	6.56E-07	2.32E-07	1.31E-06	4.77E-08	4.28E-08
SD07	129	9609	9.54E-07	5.87E-06	5.73E-06	8.52E-06	5.66E-07	2.17E-07	1.25E-06	4.40E-08	3.96E-08
SD07	130	9609	1.79E-07	1.65E-06	2.55E-06	5.28E-06	3.87E-07	4.83E-08	2.38E-07	2.40E-08	2.11E-08
SD07	131	9609	9.54E-07	5.60E-06	5.04E-06	9.00E-06	5.96E-07	2.09E-07	1.31E-06	4.31E-08	3.82E-08
SD07	132	9609	1.01E-06	5.95E-06	5.91E-06	8.97E-06	5.66E-07	2.68E-07	1.25E-06	4.67E-08	4.17E-08
SD07	133	9609	1.13E-06	6.23E-06	6.38E-06	8.97E-06	5.66E-07	3.01E-07	1.19E-06	4.84E-08	4.35E-08
SD07	134	9609	1.55E-06	8.29E-06	7.83E-06	9.09E-06	5.36E-07	4.42E-07	1.85E-06	5.44E-08	4.94E-08

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD07	135	9609	1.31E-06	6.91E-06	7.07E-06	8.85E-06	5.36E-07	3.72E-07	1.37E-06	5.11E-08	4.62E-08
SD07	136	9609	1.37E-06	7.17E-06	6.81E-06	8.67E-06	4.47E-07	4.16E-07	1.49E-06	4.98E-08	4.50E-08
SD07	137	9609	5.96E-07	3.61E-06	4.48E-06	8.08E-06	4.77E-07	1.88E-07	7.75E-07	3.99E-08	3.51E-08
SD07	138	9609	1.49E-06	8.29E-06	7.40E-06	8.52E-06	4.17E-07	4.94E-07	1.79E-06	5.20E-08	4.71E-08
SD07	139	9609	1.61E-06	9.21E-06	9.66E-06	1.38E-05	7.15E-07	5.49E-07	2.03E-06	7.23E-08	6.80E-08
SD08-2	1	820	8.48E-05	5.57E-07	5.05E-08	7.09E-07	5.59E-07	7.48E-09	1.20E-07	6.07E-09	1.11E-10
SD08-2	2	821	7.15E-05	4.33E-07	4.20E-08	5.45E-07	4.15E-07	5.44E-09	9.23E-08	5.16E-09	9.35E-11
SD08-2	3	824	4.24E-05	2.51E-07	2.59E-08	3.08E-07	2.34E-07	3.03E-09	5.15E-08	3.23E-09	5.72E-11
SD08-2	4	820	1.32E-04	1.62E-08	2.43E-09	5.12E-08	6.38E-08	4.50E-12	2.56E-09	1.56E-11	4.40E-12
SD08-2	5	821	1.13E-04	1.49E-08	2.04E-09	4.46E-08	5.72E-08	4.75E-12	2.32E-09	1.39E-11	3.92E-12
SD08-2	6	824	7.35E-05	1.05E-08	1.40E-09	3.09E-08	4.02E-08	2.95E-12	1.62E-09	9.36E-12	2.75E-12
SD08-2	7	820	1.25E-04	1.98E-08	3.16E-09	4.73E-08	7.69E-08	1.07E-12	3.87E-09	9.86E-12	8.49E-12
SD08-2	8	821	1.06E-04	1.74E-08	2.88E-09	4.09E-08	6.71E-08	1.50E-12	3.38E-09	8.74E-12	7.40E-12
SD08-2	9	824	6.54E-05	1.10E-08	1.81E-09	2.58E-08	4.25E-08	9.00E-13	2.14E-09	5.52E-12	4.68E-12
SD08-2	10	820	1.19E-04	2.34E-08	1.15E-09	3.66E-08	9.70E-08	2.99E-13	2.98E-09	6.95E-12	6.49E-12
SD08-2	11	821	1.04E-04	2.08E-08	9.79E-10	3.34E-08	8.42E-08	4.50E-13	2.61E-09	6.04E-12	5.58E-12
SD08-2	12	824	6.31E-05	1.39E-08	6.49E-10	2.22E-08	5.59E-08	3.50E-13	1.74E-09	4.02E-12	3.71E-12
SD08-2	13	820	1.06E-04	2.63E-08	5.86E-10	4.32E-08	4.78E-08	5.60E-14	3.13E-09	4.47E-12	4.28E-12
SD08-2	14	821	9.04E-05	2.21E-08	4.97E-10	3.81E-08	4.04E-08	6.71E-14	2.70E-09	3.79E-12	3.62E-12
SD08-2	15	824	5.55E-05	1.47E-08	3.31E-10	2.55E-08	2.67E-08	4.06E-14	1.81E-09	2.52E-12	2.41E-12
SD08-2	16	820	1.05E-04	2.58E-08	7.39E-10	9.00E-08	4.39E-08	2.66E-15	5.34E-09	4.32E-12	3.98E-12
SD08-2	17	821	8.71E-05	2.14E-08	6.12E-10	7.45E-08	3.63E-08	2.66E-15	4.42E-09	3.57E-12	3.29E-12
SD08-2	18	824	5.45E-05	1.44E-08	4.11E-10	5.01E-08	2.44E-08	1.55E-15	2.97E-09	2.40E-12	2.21E-12
SD08-2	19	820	1.17E-04	2.40E-08	1.68E-09	9.52E-08	4.40E-08	2.66E-15	4.76E-09	3.70E-12	3.37E-12
SD08-2	20	821	9.69E-05	1.98E-08	1.39E-09	7.88E-08	3.64E-08	1.78E-15	3.94E-09	3.06E-12	2.78E-12
SD08-2	21	824	6.09E-05	1.29E-08	9.18E-10	5.16E-08	2.39E-08	1.33E-15	2.56E-09	2.01E-12	1.83E-12
SD08-2	22	820	1.28E-04	7.74E-09	2.32E-09	3.43E-08	4.84E-08	8.88E-16	1.48E-09	3.39E-12	3.40E-12

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD08-2	23	821	1.06E-04	6.40E-09	1.92E-09	2.83E-08	4.01E-08	1.33E-15	1.23E-09	2.80E-12	2.82E-12
SD08-2	24	824	7.31E-05	4.49E-09	1.35E-09	1.97E-08	2.82E-08	4.44E-16	8.62E-10	1.97E-12	1.98E-12
SD08-2	25	820	1.39E-04	5.24E-09	2.55E-09	3.11E-09	5.36E-08	8.88E-16	1.40E-09	3.08E-12	3.12E-12
SD08-2	26	821	1.15E-04	4.34E-09	2.11E-09	2.57E-09	4.44E-08	4.44E-16	1.16E-09	2.55E-12	2.58E-12
SD08-2	27	824	7.93E-05	3.05E-09	1.48E-09	1.80E-09	3.12E-08	4.44E-16	8.14E-10	1.80E-12	1.81E-12
SD08-2	28	820	1.49E-04	4.37E-09	2.38E-09	1.88E-09	5.96E-08	0.00E+00	1.18E-09	2.65E-12	2.68E-12
SD08-2	29	821	1.24E-04	3.62E-09	1.97E-09	1.55E-09	4.94E-08	0.00E+00	9.77E-10	2.19E-12	2.22E-12
SD08-2	30	824	8.18E-05	2.45E-09	1.33E-09	1.04E-09	3.34E-08	2.22E-16	6.60E-10	1.48E-12	1.50E-12
SD08-2	31	820	1.58E-04	3.94E-09	2.69E-09	1.54E-09	7.97E-08	0.00E+00	1.06E-09	2.64E-12	2.68E-12
SD08-2	32	821	1.31E-04	3.26E-09	2.23E-09	1.27E-09	6.61E-08	0.00E+00	8.80E-10	2.18E-12	2.22E-12
SD08-2	33	824	8.71E-05	2.21E-09	1.51E-09	8.61E-10	4.50E-08	0.00E+00	5.98E-10	1.48E-12	1.51E-12
SD08-2	34	820	1.66E-04	3.17E-09	2.81E-09	1.24E-09	1.30E-07	0.00E+00	8.97E-10	2.92E-12	2.98E-12
SD08-2	35	821	1.38E-04	2.62E-09	2.33E-09	1.03E-09	1.08E-07	0.00E+00	7.43E-10	2.42E-12	2.47E-12
SD08-2	36	824	8.84E-05	1.71E-09	1.52E-09	6.69E-10	7.00E-08	0.00E+00	4.84E-10	1.57E-12	1.61E-12
SD08-2	37	820	1.73E-04	2.09E-09	2.02E-09	8.59E-10	2.20E-07	6.13E-14	1.06E-06	3.33E-12	3.40E-12
SD08-2	38	821	1.43E-04	1.73E-09	1.67E-09	7.11E-10	1.82E-07	5.15E-14	8.81E-07	2.76E-12	2.81E-12
SD08-2	39	824	9.00E-05	1.09E-09	1.05E-09	4.48E-10	1.14E-07	3.31E-14	5.57E-07	1.75E-12	1.78E-12
SD08-2	40	820	1.74E-04	1.85E-09	1.37E-09	8.05E-10	1.17E-08	3.09E-13	2.18E-08	5.35E-12	5.43E-12
SD08-2	41	821	1.44E-04	1.53E-09	1.13E-09	6.67E-10	9.64E-09	2.56E-13	1.78E-08	4.43E-12	4.50E-12
SD08-2	42	824	9.76E-05	1.05E-09	7.79E-10	4.58E-10	6.54E-09	1.76E-13	1.18E-08	3.05E-12	3.10E-12
SD08-2	43	820	1.77E-04	1.29E-09	9.77E-10	7.64E-10	4.37E-09	1.97E-13	5.09E-10	4.65E-12	4.73E-12
SD08-2	44	821	1.46E-04	1.07E-09	8.09E-10	6.33E-10	3.62E-09	1.64E-13	4.21E-10	3.85E-12	3.92E-12
SD08-2	45	824	9.91E-05	7.32E-10	5.56E-10	4.34E-10	2.48E-09	1.13E-13	2.92E-10	2.65E-12	2.69E-12
SD08-2	46	820	1.80E-04	1.09E-09	1.10E-09	7.97E-10	4.61E-09	2.28E-13	3.49E-10	5.26E-12	5.34E-12
SD08-2	47	821	1.49E-04	9.06E-10	9.12E-10	6.61E-10	3.82E-09	1.88E-13	2.89E-10	4.36E-12	4.43E-12
SD08-2	48	824	1.00E-04	6.12E-10	6.16E-10	4.46E-10	2.58E-09	1.28E-13	1.97E-10	2.94E-12	2.99E-12
SD08-2	49	820	1.82E-04	8.53E-10	1.06E-09	7.29E-10	3.72E-09	2.19E-13	2.48E-10	5.12E-12	5.20E-12

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD08-2	50	821	1.51E-04	7.06E-10	8.82E-10	6.04E-10	3.08E-09	1.82E-13	2.05E-10	4.24E-12	4.31E-12
SD08-2	51	824	1.05E-04	4.95E-10	6.20E-10	4.24E-10	2.16E-09	1.28E-13	1.45E-10	2.98E-12	3.03E-12
SD08-2	52	820	1.86E-04	7.03E-10	1.09E-09	6.98E-10	2.74E-09	2.32E-13	1.94E-10	5.24E-12	5.32E-12
SD08-2	53	821	1.54E-04	5.82E-10	9.02E-10	5.78E-10	2.27E-09	1.92E-13	1.60E-10	4.34E-12	4.40E-12
SD08-2	54	824	9.74E-05	3.68E-10	5.72E-10	3.65E-10	1.44E-09	1.22E-13	1.02E-10	2.75E-12	2.79E-12
SD08-2	55	820	1.90E-04	5.41E-10	7.14E-10	5.75E-10	2.02E-09	1.11E-13	1.44E-10	3.73E-12	3.80E-12
SD08-2	56	821	1.57E-04	4.48E-10	5.91E-10	4.76E-10	1.67E-09	9.10E-14	1.19E-10	3.09E-12	3.15E-12
SD08-2	57	824	9.71E-05	2.76E-10	3.65E-10	2.93E-10	1.03E-09	5.64E-14	7.34E-11	1.91E-12	1.94E-12
SD08-2	58	820	1.91E-04	4.13E-10	9.95E-10	5.08E-10	1.44E-09	2.18E-13	1.06E-10	4.63E-12	4.70E-12
SD08-2	59	821	1.58E-04	3.42E-10	8.23E-10	4.21E-10	1.20E-09	1.81E-13	8.83E-11	3.84E-12	3.89E-12
SD08-2	60	824	9.90E-05	2.13E-10	5.14E-10	2.62E-10	7.45E-10	1.13E-13	5.51E-11	2.39E-12	2.43E-12
SD08-2	61	820	1.92E-04	3.07E-10	8.54E-10	4.56E-10	9.44E-10	1.79E-13	7.71E-11	4.03E-12	4.09E-12
SD08-2	62	821	1.59E-04	2.55E-10	7.07E-10	3.78E-10	7.82E-10	1.48E-13	6.37E-11	3.34E-12	3.39E-12
SD08-2	63	824	9.93E-05	1.58E-10	4.40E-10	2.35E-10	4.87E-10	9.26E-14	3.96E-11	2.08E-12	2.11E-12
SD08-2	64	820	1.93E-04	2.32E-10	7.83E-10	3.97E-10	5.90E-10	1.63E-13	5.67E-11	3.68E-12	3.73E-12
SD08-2	65	821	1.60E-04	1.92E-10	6.49E-10	3.29E-10	4.89E-10	1.35E-13	4.72E-11	3.05E-12	3.09E-12
SD08-2	66	824	1.00E-04	1.20E-10	4.05E-10	2.05E-10	3.05E-10	8.44E-14	2.94E-11	1.90E-12	1.93E-12
SD08-2	67	820	1.94E-04	1.67E-10	6.59E-10	3.35E-10	3.58E-10	1.32E-13	3.99E-11	3.12E-12	3.17E-12
SD08-2	68	821	1.60E-04	1.39E-10	5.45E-10	2.77E-10	2.96E-10	1.10E-13	3.27E-11	2.58E-12	2.62E-12
SD08-2	69	824	1.01E-04	8.65E-11	3.40E-10	1.73E-10	1.85E-10	6.82E-14	2.06E-11	1.61E-12	1.64E-12
SD08-2	70	820	5.75E-05	3.02E-11	1.99E-10	9.15E-11	7.71E-11	4.09E-14	6.48E-12	9.23E-13	9.36E-13
SD08-2	71	821	4.76E-05	2.50E-11	1.65E-10	7.57E-11	6.39E-11	3.46E-14	5.68E-12	7.64E-13	7.75E-13
SD08-2	72	824	3.00E-05	1.56E-11	1.03E-10	4.74E-11	3.98E-11	2.18E-14	3.41E-12	4.78E-13	4.85E-13
SD09	1	820	1.04E-04	5.39E-05	1.17E-06	4.99E-05	4.98E-05	7.29E-07	1.27E-05	1.41E-11	1.41E-11
SD09	2	821	8.64E-05	4.47E-05	9.74E-07	4.14E-05	4.14E-05	6.04E-07	1.05E-05	1.17E-11	1.17E-11
SD09	3	824	4.69E-05	2.43E-05	5.29E-07	2.25E-05	2.25E-05	3.28E-07	5.72E-06	6.35E-12	6.35E-12
SD09	4	844	6.57E-04	5.67E-04	9.51E-05	5.39E-04	5.40E-04	1.90E-07	2.44E-05	4.85E-12	4.84E-12

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD09	5	844	7.52E-03	6.53E-03	3.13E-04	5.32E-03	5.32E-03	1.66E-05	1.31E-03	3.41E-10	3.41E-10
SD09	6	844	3.31E-02	2.48E-02	5.86E-04	2.12E-02	2.12E-02	1.34E-04	5.76E-03	2.46E-09	2.46E-09
SD09	7	844	4.03E-02	1.55E-02	2.70E-04	1.45E-02	1.45E-02	2.13E-04	3.73E-03	3.94E-09	3.94E-09
SD09	8	844	4.75E-02	1.24E-02	1.74E-04	1.27E-02	1.26E-02	2.89E-04	3.07E-03	5.57E-09	5.57E-09
SD09	9	844	4.78E-02	9.11E-03	1.25E-04	9.27E-03	9.22E-03	2.39E-04	2.27E-03	4.92E-09	4.92E-09
SD09	10	820	1.39E-04	2.84E-05	3.72E-07	2.54E-05	2.50E-05	9.29E-07	5.84E-06	3.05E-09	7.69E-11
SD09	11	821	1.15E-04	2.35E-05	3.08E-07	2.11E-05	2.08E-05	7.71E-07	4.84E-06	2.53E-09	6.37E-11
SD09	12	824	6.26E-05	1.28E-05	1.67E-07	1.15E-05	1.13E-05	4.18E-07	2.63E-06	1.37E-09	3.46E-11
SD09	13	844	4.60E-02	7.87E-03	1.08E-04	8.15E-03	8.13E-03	2.60E-04	1.97E-03	5.39E-09	5.40E-09
SD09	14	844	4.71E-02	8.55E-03	1.19E-04	9.42E-03	9.41E-03	3.76E-04	2.15E-03	7.36E-09	7.37E-09
SD09	15	844	4.17E-02	6.73E-03	9.07E-05	7.48E-03	7.48E-03	3.04E-04	1.69E-03	5.89E-09	5.90E-09
SD09	16	844	4.53E-02	6.06E-03	7.66E-05	6.58E-03	6.59E-03	2.53E-04	1.53E-03	5.05E-09	5.06E-09
SD09	17	844	4.49E-02	1.55E-02	2.06E-04	4.81E-03	4.07E-03	1.36E-04	9.48E-04	6.88E-06	1.31E-07
SD09	18	844	4.97E-02	1.10E-02	1.47E-04	5.50E-03	4.71E-03	1.50E-04	1.12E-03	3.68E-06	8.05E-08
SD09	19	820	1.08E-04	1.24E-05	1.61E-07	7.85E-06	5.75E-06	1.67E-07	1.25E-06	3.85E-09	1.11E-10
SD09	20	821	8.95E-05	1.03E-05	1.34E-07	6.51E-06	4.77E-06	1.39E-07	1.04E-06	3.20E-09	9.19E-11
SD09	21	844	4.75E-02	7.84E-03	9.47E-05	4.02E-03	3.27E-03	1.04E-04	7.76E-04	2.36E-06	5.56E-08
SD09	22	844	3.27E-02	4.01E-03	4.98E-05	2.32E-03	1.72E-03	5.39E-05	4.04E-04	1.24E-06	3.24E-08
SD09	23	844	4.03E-02	3.99E-03	4.96E-05	2.64E-03	1.80E-03	5.27E-05	3.95E-04	1.22E-06	3.67E-08
SD09	24	844	2.80E-02	2.29E-03	2.98E-05	1.76E-03	1.26E-03	3.02E-05	2.26E-04	7.09E-07	2.55E-08
SD09	25	844	3.45E-02	2.38E-03	3.50E-05	2.14E-03	1.33E-03	3.15E-05	2.36E-04	7.53E-07	3.26E-08
SD09	26	844	3.16E-02	1.78E-03	3.63E-05	1.93E-03	1.06E-03	2.37E-05	1.78E-04	5.82E-07	3.14E-08
SD09	27	844	2.19E-02	1.04E-03	3.08E-05	1.31E-03	6.53E-04	1.38E-05	1.04E-04	3.48E-07	2.28E-08
SD09	28	844	2.70E-02	1.08E-03	3.07E-05	1.58E-03	7.24E-04	1.42E-05	1.07E-04	3.69E-07	2.95E-08
SD09	29	844	1.87E-02	6.39E-04	1.79E-05	1.08E-03	4.58E-04	8.13E-06	6.20E-05	2.20E-07	2.14E-08
SD09	30	844	2.31E-02	6.65E-04	1.84E-05	1.31E-03	5.18E-04	8.23E-06	6.42E-05	2.31E-07	2.72E-08
SD09	31	844	2.10E-02	4.97E-04	1.34E-05	1.17E-03	4.32E-04	5.90E-06	4.82E-05	1.72E-07	2.54E-08

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD09	32	844	1.44E-02	2.95E-04	7.56E-06	8.17E-04	2.82E-04	3.30E-06	2.90E-05	1.01E-07	1.84E-08
SD09	33	844	1.77E-02	3.27E-04	7.88E-06	1.02E-03	3.33E-04	3.39E-06	3.38E-05	1.09E-07	2.39E-08
SD09	34	844	1.22E-02	2.12E-04	4.69E-06	7.24E-04	2.27E-04	1.98E-06	2.33E-05	6.80E-08	1.78E-08
SD09	35	844	1.51E-02	2.56E-04	5.10E-06	9.32E-04	2.89E-04	2.12E-06	3.04E-05	7.83E-08	2.42E-08
SD09	36	844	1.38E-02	2.39E-04	4.14E-06	9.14E-04	2.80E-04	1.67E-06	3.11E-05	6.81E-08	2.50E-08
SD09	37	844	9.47E-03	1.71E-04	2.61E-06	6.67E-04	2.03E-04	1.03E-06	2.38E-05	4.58E-08	1.91E-08
SD09	38	844	1.18E-02	2.31E-04	3.00E-06	8.53E-04	2.59E-04	1.16E-06	3.55E-05	5.57E-08	2.55E-08
SD09	39	844	8.14E-03	1.73E-04	1.94E-06	6.24E-04	1.89E-04	7.30E-07	2.81E-05	3.86E-08	1.95E-08
SD09	40	844	1.01E-02	2.26E-04	2.25E-06	7.98E-04	2.43E-04	8.29E-07	3.84E-05	4.80E-08	2.61E-08
SD09	41	844	9.45E-03	2.37E-04	1.94E-06	7.06E-04	2.16E-04	7.08E-07	4.45E-05	4.20E-08	2.33E-08
SD09	42	844	6.54E-03	1.70E-04	1.23E-06	4.44E-04	1.36E-04	4.52E-07	3.37E-05	2.65E-08	1.46E-08
SD09	43	844	7.78E-03	1.84E-04	1.36E-06	4.88E-04	1.49E-04	4.96E-07	3.64E-05	2.92E-08	1.61E-08
SD09	44	844	7.20E-04	1.51E-05	1.10E-07	3.95E-05	1.21E-05	4.05E-08	2.98E-06	2.36E-09	1.30E-09
SD09	45	844	4.51E-04	8.78E-06	6.40E-08	2.30E-05	7.03E-06	2.33E-08	1.74E-06	1.38E-09	7.60E-10
SD09	46	844	6.28E-03	1.18E-04	8.62E-07	3.11E-04	9.52E-05	3.15E-07	2.34E-05	1.86E-08	1.03E-08
SD09	47	844	6.39E-03	1.15E-04	8.35E-07	3.02E-04	9.25E-05	3.05E-07	2.27E-05	1.80E-08	1.00E-08
SD09	48	844	6.53E-03	1.11E-04	8.10E-07	2.95E-04	9.08E-05	2.95E-07	2.20E-05	1.76E-08	9.83E-09
SD09	49	844	3.99E-03	6.57E-05	4.79E-07	1.76E-04	5.44E-05	1.74E-07	1.29E-05	1.05E-08	5.90E-09
SD09	50	844	4.93E-03	7.60E-05	5.55E-07	2.06E-04	6.41E-05	2.00E-07	1.49E-05	1.22E-08	6.96E-09
SD09	51	844	4.52E-03	6.49E-05	4.75E-07	1.78E-04	5.59E-05	1.71E-07	1.27E-05	1.06E-08	6.08E-09
SD09	52	844	1.78E-03	2.43E-05	1.79E-07	6.77E-05	2.14E-05	6.38E-08	4.76E-06	4.01E-09	2.33E-09
SD11-1	1	27	4.18E-03	1.48E-06	8.39E-08	1.04E-06	1.14E-06	3.01E-09	2.88E-07	6.60E-14	6.60E-14
SD11-1	2	27	1.91E-02	2.83E-06	5.14E-08	2.70E-06	2.47E-06	1.78E-08	6.71E-07	3.47E-13	3.47E-13
SD11-1	3	27	2.19E-03	3.26E-07	1.84E-09	3.26E-07	3.94E-07	4.80E-09	8.33E-08	8.53E-14	8.54E-14
SD11-1	4	995	1.03E-01	1.20E-02	7.83E-05	1.16E-02	1.25E-02	1.94E-04	3.06E-03	3.60E-09	3.61E-09
SD11-1	5	997	1.42E-03	8.28E-05	6.27E-07	7.33E-05	7.91E-05	1.05E-06	2.10E-05	1.89E-11	1.89E-11
SD11-1	6	998	2.12E-03	1.24E-04	1.00E-06	1.15E-04	1.21E-04	1.66E-06	3.11E-05	2.97E-11	2.97E-11

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD11-1	7	995	1.09E-01	4.05E-03	3.49E-05	4.45E-03	4.47E-03	1.14E-04	1.03E-03	2.36E-09	2.36E-09
SD11-1	8	995	9.00E-02	2.97E-03	3.65E-05	3.37E-03	3.37E-03	1.49E-04	7.46E-04	2.82E-09	2.82E-09
SD11-1	9	995	8.54E-02	4.01E-03	4.21E-05	4.50E-03	4.61E-03	1.53E-04	1.02E-03	2.90E-09	2.91E-09
SD11-1	10	995	6.83E-02	1.68E-03	1.73E-05	4.67E-03	5.14E-03	5.50E-05	2.78E-04	1.11E-09	1.12E-09
SD11-1	11	995	4.80E-02	6.11E-04	1.90E-04	2.20E-03	1.55E-03	1.22E-05	9.59E-05	3.70E-09	3.91E-09
SD11-1	12	820	2.98E-06	3.96E-06	1.00E-06	1.28E-06	7.76E-07	3.26E-09	9.38E-07	7.26E-08	1.19E-09
SD11-1	13	821	2.47E-06	3.28E-06	8.30E-07	1.06E-06	6.44E-07	2.70E-09	7.77E-07	6.02E-08	9.87E-10
SD11-1	14	824	1.33E-06	1.78E-06	4.49E-07	5.76E-07	3.48E-07	1.46E-09	4.21E-07	3.26E-08	5.35E-10
SD11-1	15	995	4.30E-02	3.56E-04	8.87E-05	4.17E-04	3.06E-04	4.71E-06	8.54E-05	3.24E-08	3.13E-09
SD11-1	16	995	3.96E-02	1.16E-04	9.77E-06	2.52E-04	1.35E-04	2.64E-06	2.42E-05	1.01E-07	1.90E-09
SD11-1	17	995	1.79E-02	4.86E-05	2.03E-06	1.55E-04	5.68E-05	1.15E-06	9.25E-06	3.94E-08	7.01E-10
SD11-1	18	995	3.26E-02	9.39E-05	2.65E-06	4.74E-04	1.14E-04	1.86E-06	1.47E-05	5.63E-08	1.02E-09
SD11-1	19	995	2.90E-02	9.91E-05	2.00E-06	7.56E-04	1.07E-04	1.33E-06	1.04E-05	3.75E-08	7.13E-10
SD11-1	20	995	2.60E-02	9.92E-05	1.81E-06	8.84E-04	1.14E-04	9.40E-07	7.36E-06	2.40E-08	4.88E-10
SD11-1	21	820	3.63E-06	1.90E-07	7.38E-08	2.45E-07	2.57E-07	3.09E-10	3.94E-08	2.97E-09	1.07E-10
SD11-1	22	821	3.04E-06	1.59E-07	6.25E-08	2.06E-07	2.16E-07	2.59E-10	3.30E-08	2.49E-09	8.98E-11
SD11-1	23	824	1.65E-06	8.61E-08	3.39E-08	1.11E-07	1.17E-07	1.41E-10	1.79E-08	1.35E-09	4.87E-11
SD11-1	24	995	2.33E-02	9.35E-05	1.78E-06	9.64E-04	1.24E-04	6.22E-07	4.94E-06	1.47E-08	3.28E-10
SD11-1	25	995	1.08E-02	4.84E-05	6.68E-07	5.65E-04	6.39E-05	2.22E-07	1.80E-06	5.30E-09	1.31E-10
SD11-1	26	995	1.99E-02	1.08E-04	1.17E-06	1.35E-03	1.35E-04	3.29E-07	2.74E-06	8.30E-09	2.30E-10
SD11-1	27	995	1.80E-02	6.51E-05	1.03E-06	7.97E-04	1.14E-04	2.21E-07	1.75E-06	5.48E-09	2.01E-10
SD11-1	28	995	1.63E-02	3.80E-05	1.18E-06	4.40E-04	1.16E-04	1.71E-07	1.22E-06	4.13E-09	2.04E-10
SD11-1	29	995	1.34E-02	2.53E-05	1.47E-06	2.70E-04	1.20E-04	1.56E-07	8.66E-07	3.04E-09	2.46E-10
SD11-1	30	820	3.97E-06	1.18E-07	2.62E-08	2.90E-07	1.70E-07	8.63E-11	1.34E-08	6.14E-10	9.20E-11
SD11-1	31	821	3.32E-06	9.87E-08	2.18E-08	2.41E-07	1.42E-07	7.21E-11	1.12E-08	5.12E-10	7.70E-11
SD11-1	32	824	1.80E-06	5.35E-08	1.18E-08	1.31E-07	7.69E-08	3.91E-11	6.09E-09	2.77E-10	4.17E-11
SD11-1	33	995	1.35E-02	2.02E-05	1.90E-06	1.86E-04	1.40E-04	1.60E-07	7.59E-07	3.18E-09	3.77E-10

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD11-1	34	995	6.25E-03	9.25E-06	8.85E-07	7.78E-05	7.32E-05	7.60E-08	3.21E-07	1.49E-09	2.18E-10
SD11-1	35	995	1.16E-02	1.86E-05	1.56E-06	1.47E-04	1.43E-04	1.41E-07	5.48E-07	2.75E-09	4.80E-10
SD11-1	36	995	1.06E-02	2.04E-05	1.51E-06	1.48E-04	1.51E-04	1.31E-07	4.59E-07	2.40E-09	5.02E-10
SD11-1	37	995	9.65E-03	2.10E-05	1.59E-06	1.60E-04	1.75E-04	1.26E-07	4.13E-07	2.11E-09	5.17E-10
SD11-1	38	995	8.87E-03	2.03E-05	1.65E-06	1.69E-04	1.79E-04	1.09E-07	3.66E-07	1.91E-09	5.16E-10
SD11-1	39	820	3.72E-06	1.03E-07	8.14E-09	2.35E-07	1.57E-07	2.77E-11	1.57E-08	2.34E-10	7.87E-11
SD11-1	40	821	3.08E-06	8.56E-08	6.75E-09	1.95E-07	1.30E-07	2.29E-11	1.30E-08	1.94E-10	6.52E-11
SD11-1	41	824	1.67E-06	4.63E-08	3.65E-09	1.05E-07	7.06E-08	1.24E-11	7.02E-09	1.05E-10	3.53E-11
SD11-1	42	995	4.12E-03	1.15E-05	9.30E-07	9.73E-05	9.56E-05	5.29E-08	1.70E-07	7.77E-10	2.28E-10
SD11-1	43	995	7.67E-03	2.41E-05	2.06E-06	1.95E-04	2.07E-04	1.06E-07	3.36E-07	1.41E-09	4.67E-10
SD11-1	44	995	6.99E-03	1.70E-05	2.26E-06	1.04E-04	2.27E-04	1.02E-07	3.32E-07	1.23E-09	4.66E-10
SD11-1	45	995	6.38E-03	1.10E-05	2.39E-06	7.47E-05	2.43E-04	9.95E-08	3.45E-07	1.13E-09	4.81E-10
SD11-1	46	995	5.84E-03	9.63E-06	2.56E-06	7.25E-05	2.74E-04	9.78E-08	3.64E-07	1.07E-09	4.99E-10
SD11-1	47	995	2.73E-03	4.94E-06	1.37E-06	3.85E-05	1.50E-04	4.78E-08	1.89E-07	5.13E-10	2.55E-10
SD11-1	48	820	4.28E-06	1.46E-07	5.47E-09	3.70E-07	2.26E-07	1.38E-11	2.93E-08	1.67E-10	9.01E-11
SD11-1	49	821	3.59E-06	1.23E-07	4.59E-09	3.07E-07	1.89E-07	1.18E-11	2.46E-08	1.39E-10	7.56E-11
SD11-1	50	824	1.94E-06	6.65E-08	2.49E-09	1.66E-07	1.03E-07	6.38E-12	1.33E-08	7.56E-11	4.09E-11
SD11-1	51	995	5.11E-03	1.04E-05	2.85E-06	8.39E-05	3.26E-04	9.23E-08	3.88E-07	9.85E-10	5.18E-10
SD11-1	52	995	2.59E-03	5.98E-06	1.53E-06	5.03E-05	1.92E-04	4.83E-08	2.16E-07	5.15E-10	2.86E-10
SD11-1	53	995	4.45E-03	1.20E-05	2.63E-06	1.04E-04	3.83E-04	8.55E-08	4.09E-07	9.20E-10	5.36E-10
SD11-1	54	995	4.08E-03	1.38E-05	2.39E-06	1.21E-04	4.16E-04	7.99E-08	4.16E-07	8.79E-10	5.42E-10
SD11-1	55	995	3.76E-03	1.51E-05	2.22E-06	1.25E-04	4.43E-04	7.22E-08	4.19E-07	8.57E-10	5.54E-10
SD11-1	56	995	3.44E-03	1.58E-05	2.15E-06	9.81E-05	4.63E-04	5.93E-08	3.80E-07	7.52E-10	4.99E-10
SD11-1	57	820	4.70E-06	1.60E-07	4.90E-09	2.13E-07	3.20E-07	7.84E-12	3.89E-08	1.22E-10	8.86E-11
SD11-1	58	821	3.89E-06	1.33E-07	4.06E-09	1.77E-07	2.65E-07	6.50E-12	3.22E-08	1.01E-10	7.35E-11
SD11-1	59	824	2.11E-06	7.18E-08	2.20E-09	9.57E-08	1.44E-07	3.52E-12	1.74E-08	5.47E-11	3.98E-11
SD11-1	60	995	3.14E-03	1.28E-05	2.22E-06	8.80E-05	4.76E-04	5.55E-08	3.79E-07	6.96E-10	4.90E-10

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD11-1	61	995	2.87E-03	1.17E-05	2.34E-06	9.06E-05	5.02E-04	5.22E-08	3.95E-07	6.97E-10	5.14E-10
SD11-1	62	995	2.62E-03	1.25E-05	2.46E-06	9.83E-05	5.28E-04	4.90E-08	4.07E-07	6.96E-10	5.32E-10
SD11-1	63	995	2.41E-03	1.99E-05	2.53E-06	1.13E-04	5.44E-04	4.54E-08	4.13E-07	6.89E-10	5.42E-10
SD11-1	64	995	2.20E-03	2.52E-05	2.49E-06	8.88E-05	5.38E-04	4.03E-08	4.01E-07	6.60E-10	5.33E-10
SD11-1	65	995	2.02E-03	2.33E-05	2.47E-06	5.85E-05	5.34E-04	3.57E-08	3.91E-07	6.39E-10	5.28E-10
SD11-1	66	820	3.98E-06	1.49E-07	4.55E-09	1.22E-07	3.82E-07	3.45E-12	3.83E-08	9.31E-11	7.84E-11
SD11-1	67	821	3.30E-06	1.24E-07	3.77E-09	1.01E-07	3.16E-07	2.86E-12	3.17E-08	7.72E-11	6.50E-11
SD11-1	68	824	1.79E-06	6.69E-08	2.04E-09	5.47E-08	1.71E-07	1.55E-12	1.72E-08	4.18E-11	3.52E-11
SD11-1	69	995	1.85E-03	3.13E-05	2.41E-06	6.37E-05	4.68E-04	3.14E-08	3.77E-07	6.14E-10	5.17E-10
SD11-1	70	995	1.70E-03	3.70E-05	2.30E-06	7.04E-05	4.04E-04	2.68E-08	3.54E-07	5.79E-10	4.97E-10
SD11-1	71	995	1.56E-03	2.53E-05	2.25E-06	6.56E-05	3.79E-04	2.32E-08	3.42E-07	5.62E-10	4.90E-10
SD11-1	72	995	1.44E-03	1.60E-05	2.30E-06	6.50E-05	3.74E-04	2.12E-08	3.46E-07	5.74E-10	5.08E-10
SD11-1	73	995	1.32E-03	1.02E-05	2.33E-06	4.88E-05	2.73E-04	1.91E-08	3.47E-07	5.86E-10	5.24E-10
SD11-1	74	820	4.05E-06	1.43E-07	4.87E-09	9.20E-08	3.61E-07	2.06E-12	3.74E-08	8.70E-11	7.84E-11
SD11-1	75	821	3.36E-06	1.18E-07	4.04E-09	7.62E-08	3.00E-07	1.71E-12	3.10E-08	7.21E-11	6.50E-11
SD11-1	76	824	1.82E-06	6.42E-08	2.19E-09	4.13E-08	1.62E-07	9.25E-13	1.68E-08	3.91E-11	3.52E-11
SD11-1	77	995	1.21E-03	1.18E-05	2.30E-06	9.66E-05	1.69E-04	1.68E-08	3.39E-07	5.86E-10	5.30E-10
SD11-1	78	995	1.12E-03	8.64E-06	2.27E-06	6.73E-05	1.23E-04	1.50E-08	3.33E-07	5.88E-10	5.37E-10
SD11-1	79	995	1.03E-03	9.67E-06	2.23E-06	9.15E-05	1.03E-04	1.29E-08	3.27E-07	5.92E-10	5.45E-10
SD11-1	80	995	9.50E-04	1.03E-05	2.20E-06	1.06E-04	9.26E-05	1.14E-08	3.27E-07	6.11E-10	5.67E-10
SD11-1	81	995	8.78E-04	6.53E-06	2.19E-06	5.69E-05	8.60E-05	9.90E-09	3.26E-07	6.26E-10	5.85E-10
SD11-1	82	820	4.91E-06	1.47E-07	6.11E-09	8.40E-08	4.27E-07	1.45E-12	3.87E-08	9.59E-11	9.03E-11
SD11-1	83	821	4.07E-06	1.22E-07	5.06E-09	6.97E-08	3.54E-07	1.20E-12	3.20E-08	7.95E-11	7.48E-11
SD11-1	84	824	2.21E-06	6.61E-08	2.74E-09	3.78E-08	1.92E-07	6.49E-13	1.74E-08	4.31E-11	4.06E-11
SD11-1	85	995	8.11E-04	5.55E-06	2.15E-06	4.58E-05	8.11E-05	8.67E-09	3.22E-07	6.33E-10	5.95E-10
SD11-1	86	995	7.50E-04	4.82E-06	2.10E-06	3.76E-05	7.71E-05	7.57E-09	3.15E-07	6.43E-10	6.08E-10
SD11-1	87	995	6.95E-04	6.21E-06	2.00E-06	5.83E-05	7.28E-05	6.40E-09	3.12E-07	6.57E-10	6.24E-10

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD11-1	88	995	6.45E-04	6.64E-06	1.89E-06	6.54E-05	6.87E-05	5.47E-09	3.01E-07	6.58E-10	6.28E-10
SD11-1	89	995	6.00E-04	6.56E-06	1.78E-06	6.52E-05	6.44E-05	4.48E-09	2.88E-07	6.52E-10	6.26E-10
SD11-1	90	995	5.58E-04	8.01E-06	1.65E-06	8.59E-05	4.64E-05	3.84E-09	2.71E-07	6.38E-10	6.15E-10
SD11-1	91	820	4.10E-06	9.88E-08	5.30E-09	5.71E-08	3.79E-07	7.18E-13	2.59E-08	7.37E-11	7.12E-11
SD11-1	92	821	3.40E-06	8.19E-08	4.39E-09	4.73E-08	3.14E-07	5.95E-13	2.15E-08	6.11E-11	5.90E-11
SD11-1	93	824	1.84E-06	4.44E-08	2.38E-09	2.56E-08	1.70E-07	3.23E-13	1.16E-08	3.31E-11	3.20E-11
SD11-1	94	995	5.19E-04	1.25E-05	1.52E-06	1.49E-04	3.53E-05	3.03E-09	2.55E-07	6.22E-10	6.02E-10
SD11-1	95	995	4.84E-04	7.74E-06	1.41E-06	8.25E-05	2.91E-05	2.50E-09	2.42E-07	6.13E-10	5.95E-10
SD11-1	96	995	4.53E-04	7.03E-06	1.31E-06	7.24E-05	2.62E-05	1.98E-09	2.29E-07	6.06E-10	5.91E-10
SD11-1	97	995	4.24E-04	7.23E-06	1.23E-06	7.47E-05	2.47E-05	1.69E-09	2.22E-07	6.11E-10	5.97E-10
SD11-1	98	995	3.98E-04	6.99E-06	1.14E-06	7.13E-05	2.36E-05	1.40E-09	2.12E-07	6.10E-10	5.98E-10
SD11-1	99	820	4.90E-06	9.14E-08	6.85E-09	5.52E-08	5.32E-07	5.34E-13	2.40E-08	8.28E-11	8.14E-11
SD11-1	100	821	4.06E-06	7.58E-08	5.68E-09	4.57E-08	4.41E-07	4.43E-13	1.99E-08	6.86E-11	6.75E-11
SD11-1	101	824	2.20E-06	4.11E-08	3.08E-09	2.48E-08	2.39E-07	2.40E-13	1.08E-08	3.72E-11	3.66E-11
SD11-1	102	995	3.75E-04	8.76E-06	1.03E-06	9.61E-05	2.31E-05	1.11E-09	2.00E-07	6.04E-10	5.94E-10
SD11-1	103	995	3.53E-04	1.27E-05	8.91E-07	1.53E-04	2.31E-05	8.73E-10	1.87E-07	5.90E-10	5.81E-10
SD11-1	104	995	3.33E-04	1.64E-05	7.88E-07	2.05E-04	2.31E-05	6.40E-10	1.75E-07	5.76E-10	5.69E-10
SD11-1	105	995	3.15E-04	1.80E-05	6.93E-07	2.29E-04	2.26E-05	5.82E-10	1.60E-07	5.58E-10	5.53E-10
SD11-1	106	995	2.99E-04	1.81E-05	5.50E-07	2.31E-04	2.21E-05	4.07E-10	1.49E-07	5.50E-10	5.46E-10
SD11-1	107	995	2.84E-04	1.10E-05	3.58E-07	1.33E-04	1.99E-05	2.91E-10	1.39E-07	5.37E-10	5.34E-10
SD11-1	108	820	4.04E-06	5.73E-08	7.03E-09	3.79E-08	6.02E-07	2.81E-13	1.51E-08	6.68E-11	6.66E-11
SD11-1	109	821	3.35E-06	4.75E-08	5.83E-09	3.14E-08	4.99E-07	2.33E-13	1.25E-08	5.54E-11	5.52E-11
SD11-1	110	824	1.82E-06	2.58E-08	3.16E-09	1.71E-08	2.71E-07	1.27E-13	6.77E-09	3.00E-11	2.99E-11
SD11-1	111	995	2.71E-04	7.06E-06	2.46E-07	7.82E-05	1.95E-05	2.33E-10	1.37E-07	5.58E-10	5.56E-10
SD11-1	112	995	2.59E-04	1.35E-05	1.54E-07	1.69E-04	2.14E-05	2.91E-10	1.32E-07	5.69E-10	5.69E-10
SD11-1	113	995	2.48E-04	1.58E-05	1.15E-07	2.01E-04	2.06E-05	1.16E-10	1.22E-07	5.58E-10	5.58E-10
SD11-1	114	995	2.37E-04	1.22E-05	9.77E-08	1.50E-04	1.83E-05	1.16E-10	1.12E-07	5.50E-10	5.52E-10

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD11-1	115	995	2.28E-04	1.56E-05	9.45E-08	1.99E-04	1.90E-05	5.82E-11	1.10E-07	5.65E-10	5.67E-10
SD11-1	116	820	3.98E-06	4.42E-08	1.05E-08	3.19E-08	1.20E-06	2.03E-13	1.30E-05	6.86E-11	6.91E-11
SD11-1	117	821	3.30E-06	3.67E-08	8.69E-09	2.65E-08	9.98E-07	1.69E-13	1.08E-05	5.69E-11	5.73E-11
SD11-1	118	824	1.79E-06	1.99E-08	4.71E-09	1.44E-08	5.41E-07	9.11E-14	5.82E-06	3.09E-11	3.11E-11
SD11-1	119	995	2.20E-04	1.13E-05	9.58E-08	1.39E-04	1.83E-05	5.82E-11	1.10E-07	5.74E-10	5.78E-10
SD11-1	120	995	2.12E-04	9.09E-06	1.02E-07	1.10E-04	1.89E-05	1.16E-10	1.22E-07	5.95E-10	6.00E-10
SD11-1	121	995	2.05E-04	1.03E-05	1.08E-07	1.28E-04	2.05E-05	5.82E-11	1.51E-07	6.01E-10	6.07E-10
SD11-1	122	995	1.99E-04	9.55E-06	1.15E-07	1.19E-04	2.35E-05	0.00E+00	2.35E-07	6.10E-10	6.17E-10
SD11-1	123	995	1.94E-04	6.55E-06	1.02E-07	7.90E-05	2.73E-05	0.00E+00	5.96E-04	5.03E-10	5.09E-10
SD11-1	124	820	4.68E-06	6.60E-07	1.07E-08	1.15E-08	9.86E-07	7.78E-13	3.85E-05	4.67E-11	5.01E-11
SD11-1	125	821	3.88E-06	5.48E-07	8.88E-09	9.52E-09	8.18E-07	6.45E-13	3.20E-05	3.88E-11	4.15E-11
SD11-1	126	824	2.11E-06	2.97E-07	4.82E-09	5.17E-09	4.44E-07	3.50E-13	1.73E-05	2.10E-11	2.25E-11
SD11-1	127	995	1.88E-04	5.32E-06	9.66E-08	3.85E-05	2.44E-05	1.16E-10	6.19E-04	4.06E-10	4.16E-10
SD11-1	128	995	1.84E-04	7.40E-06	8.25E-08	3.02E-05	1.60E-05	0.00E+00	3.31E-04	3.71E-10	3.95E-10
SD11-1	129	995	1.79E-04	9.45E-06	9.12E-08	2.96E-05	1.20E-05	5.82E-11	2.20E-04	3.92E-10	4.27E-10
SD11-1	130	995	1.75E-04	1.13E-05	1.07E-07	2.94E-05	9.72E-06	5.82E-11	1.67E-04	4.38E-10	4.82E-10
SD11-1	131	995	1.71E-04	1.30E-05	1.22E-07	2.88E-05	8.15E-06	1.16E-10	1.33E-04	4.84E-10	5.37E-10
SD11-1	132	995	1.67E-04	1.45E-05	1.45E-07	2.90E-05	7.12E-06	1.16E-10	1.11E-04	5.49E-10	6.08E-10
SD11-1	133	820	3.81E-06	1.31E-06	1.60E-08	7.27E-09	2.66E-07	1.66E-12	8.84E-06	5.82E-11	6.44E-11
SD11-1	134	821	3.16E-06	1.08E-06	1.33E-08	6.03E-09	2.21E-07	1.38E-12	7.33E-06	4.82E-11	5.34E-11
SD11-1	135	824	1.71E-06	5.87E-07	7.20E-09	3.27E-09	1.20E-07	7.46E-13	3.98E-06	2.62E-11	2.89E-11
SD11-1	136	995	1.62E-04	1.41E-05	1.35E-07	3.47E-05	8.37E-06	1.16E-10	8.19E-05	5.00E-10	5.55E-10
SD11-1	137	995	1.59E-04	1.37E-05	1.23E-07	3.81E-05	8.47E-06	1.75E-10	6.23E-05	4.58E-10	5.09E-10
SD11-1	138	995	1.56E-04	1.34E-05	1.35E-07	3.06E-05	7.10E-06	5.82E-11	5.25E-05	4.82E-10	5.34E-10
SD11-1	139	995	1.55E-04	1.37E-05	1.46E-07	3.18E-05	5.79E-06	5.82E-11	4.51E-05	5.02E-10	5.53E-10
SD11-1	140	995	1.53E-04	1.46E-05	1.61E-07	3.66E-05	4.82E-06	1.16E-10	4.07E-05	5.36E-10	5.88E-10
SD11-1	141	820	4.43E-06	1.81E-06	2.96E-08	1.03E-08	1.74E-07	3.18E-12	5.98E-06	9.40E-11	1.02E-10

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD11-1	142	821	3.68E-06	1.50E-06	2.45E-08	8.53E-09	1.44E-07	2.63E-12	4.96E-06	7.79E-11	8.47E-11
SD11-1	143	824	1.99E-06	8.14E-07	1.33E-08	4.63E-09	7.81E-08	1.43E-12	2.69E-06	4.23E-11	4.59E-11
SD11-1	144	995	1.51E-04	1.48E-05	1.77E-07	3.24E-05	4.00E-06	5.82E-11	3.75E-05	5.73E-10	6.26E-10
SD11-1	145	995	1.50E-04	1.52E-05	1.94E-07	2.91E-05	3.27E-06	0.00E+00	3.50E-05	6.13E-10	6.65E-10
SD11-1	146	995	1.49E-04	1.54E-05	2.09E-07	3.00E-05	2.74E-06	0.00E+00	3.27E-05	6.45E-10	6.98E-10
SD11-1	147	995	1.48E-04	1.32E-05	2.24E-07	2.86E-05	2.30E-06	5.82E-11	3.00E-05	6.76E-10	7.28E-10
SD11-1	148	995	1.48E-04	1.09E-05	2.32E-07	1.88E-05	1.98E-06	0.00E+00	2.77E-05	6.95E-10	7.47E-10
SD11-1	149	995	1.47E-04	9.29E-06	2.29E-07	8.68E-06	1.72E-06	1.16E-10	2.56E-05	6.93E-10	7.46E-10
SD11-1	150	820	3.57E-06	1.00E-06	2.94E-08	9.60E-09	8.81E-08	2.96E-12	3.06E-06	8.70E-11	9.32E-11
SD11-1	151	821	2.96E-06	8.31E-07	2.44E-08	7.96E-09	7.30E-08	2.46E-12	2.54E-06	7.21E-11	7.73E-11
SD11-1	152	824	1.61E-06	4.51E-07	1.32E-08	4.32E-09	3.96E-08	1.33E-12	1.38E-06	3.91E-11	4.19E-11
SD11-1	153	995	1.46E-04	8.28E-06	2.27E-07	4.23E-06	1.52E-06	0.00E+00	2.38E-05	6.91E-10	7.44E-10
SD11-1	154	995	1.45E-04	7.49E-06	2.42E-07	2.38E-06	1.27E-06	5.82E-11	2.19E-05	7.14E-10	7.65E-10
SD11-1	155	995	1.45E-04	6.82E-06	2.55E-07	1.48E-06	1.33E-06	0.00E+00	2.01E-05	7.34E-10	7.82E-10
SD11-1	156	995	1.44E-04	6.34E-06	2.68E-07	9.83E-07	1.33E-06	0.00E+00	1.88E-05	7.56E-10	8.04E-10
SD11-1	157	995	1.44E-04	5.93E-06	3.12E-07	6.82E-07	1.13E-06	1.16E-10	1.76E-05	7.78E-10	8.24E-10
SD11-1	158	820	3.45E-06	6.68E-07	3.38E-08	1.01E-08	5.91E-08	3.34E-12	2.04E-06	9.29E-11	9.83E-11
SD11-1	159	821	2.86E-06	5.54E-07	2.80E-08	8.36E-09	4.90E-08	2.77E-12	1.70E-06	7.70E-11	8.15E-11
SD11-1	160	824	1.55E-06	3.01E-07	1.52E-08	4.54E-09	2.66E-08	1.50E-12	9.20E-07	4.18E-11	4.42E-11
SD11-1	161	995	1.43E-04	5.61E-06	4.74E-07	4.92E-07	1.16E-06	0.00E+00	1.67E-05	8.06E-10	8.52E-10
SD11-1	162	995	1.43E-04	5.32E-06	6.24E-07	3.80E-07	1.20E-06	0.00E+00	1.59E-05	8.32E-10	8.78E-10
SD11-1	163	995	1.42E-04	5.01E-06	6.97E-07	3.02E-07	1.16E-06	5.82E-11	1.50E-05	8.52E-10	8.97E-10
SD11-1	164	995	1.41E-04	4.71E-06	6.44E-07	2.53E-07	1.06E-06	5.82E-11	1.41E-05	8.63E-10	9.07E-10
SD11-1	165	995	1.41E-04	4.43E-06	5.32E-07	2.16E-07	9.61E-07	0.00E+00	1.33E-05	8.51E-10	8.94E-10
SD11-1	166	820	3.98E-06	5.31E-07	4.26E-08	1.24E-08	4.73E-08	3.96E-12	1.63E-06	1.12E-10	1.17E-10
SD11-1	167	821	3.30E-06	4.41E-07	3.53E-08	1.03E-08	3.92E-08	3.28E-12	1.35E-06	9.25E-11	9.70E-11
SD11-1	168	824	1.79E-06	2.39E-07	1.92E-08	5.56E-09	2.13E-08	1.78E-12	7.32E-07	5.02E-11	5.26E-11

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD11-1	169	995	1.40E-04	4.15E-06	4.28E-07	1.94E-07	8.61E-07	0.00E+00	1.24E-05	8.45E-10	8.88E-10
SD11-1	170	995	1.40E-04	3.88E-06	3.82E-07	1.75E-07	7.45E-07	1.16E-10	1.16E-05	8.65E-10	9.06E-10
SD11-1	171	995	1.39E-04	3.66E-06	3.74E-07	1.71E-07	6.78E-07	0.00E+00	1.09E-05	8.88E-10	9.28E-10
SD11-1	172	995	1.38E-04	3.45E-06	3.70E-07	1.60E-07	6.74E-07	0.00E+00	1.03E-05	8.98E-10	9.37E-10
SD11-1	173	995	1.37E-04	3.25E-06	3.57E-07	1.56E-07	6.26E-07	0.00E+00	9.72E-06	8.86E-10	9.25E-10
SD11-1	174	995	1.36E-04	3.05E-06	3.66E-07	1.53E-07	6.04E-07	5.82E-11	9.13E-06	9.04E-10	9.41E-10
SD11-1	175	820	3.19E-06	2.99E-07	3.72E-08	1.03E-08	2.68E-08	3.30E-12	9.14E-07	9.30E-11	9.67E-11
SD11-1	176	821	2.64E-06	2.48E-07	3.09E-08	8.54E-09	2.22E-08	2.74E-12	7.58E-07	7.71E-11	8.02E-11
SD11-1	177	824	1.43E-06	1.34E-07	1.68E-08	4.64E-09	1.20E-08	1.49E-12	4.11E-07	4.19E-11	4.35E-11
SD11-1	178	995	1.36E-04	2.87E-06	3.73E-07	1.49E-07	5.63E-07	5.82E-11	8.59E-06	9.17E-10	9.53E-10
SD11-1	179	995	1.35E-04	2.71E-06	3.82E-07	1.45E-07	5.07E-07	0.00E+00	8.10E-06	9.33E-10	9.68E-10
SD11-1	180	995	1.34E-04	2.56E-06	3.91E-07	1.42E-07	4.69E-07	0.00E+00	7.65E-06	9.47E-10	9.80E-10
SD11-1	181	995	1.33E-04	2.42E-06	3.79E-07	1.45E-07	4.14E-07	1.16E-10	7.25E-06	9.28E-10	9.61E-10
SD11-1	182	995	1.32E-04	2.28E-06	3.70E-07	1.42E-07	3.76E-07	0.00E+00	6.82E-06	9.10E-10	9.43E-10
SD11-1	183	820	3.66E-06	2.48E-07	4.61E-08	1.22E-08	2.23E-08	3.89E-12	7.57E-07	1.10E-10	1.14E-10
SD11-1	184	821	3.04E-06	2.05E-07	3.82E-08	1.01E-08	1.85E-08	3.23E-12	6.28E-07	9.16E-11	9.46E-11
SD11-1	185	824	1.65E-06	1.12E-07	2.07E-08	5.48E-09	1.00E-08	1.75E-12	3.41E-07	4.97E-11	5.14E-11
SD11-1	186	995	1.31E-04	2.14E-06	3.88E-07	1.42E-07	3.39E-07	5.82E-11	6.40E-06	9.35E-10	9.66E-10
SD11-1	187	995	1.30E-04	2.03E-06	4.00E-07	1.38E-07	3.09E-07	0.00E+00	6.04E-06	9.52E-10	9.82E-10
SD11-1	188	995	1.29E-04	1.91E-06	4.09E-07	1.42E-07	2.72E-07	1.16E-10	5.71E-06	9.63E-10	9.93E-10
SD11-1	189	995	1.28E-04	1.81E-06	4.16E-07	1.34E-07	2.53E-07	0.00E+00	5.39E-06	9.73E-10	1.00E-09
SD11-1	190	995	1.27E-04	1.71E-06	4.22E-07	1.38E-07	2.24E-07	0.00E+00	5.08E-06	9.78E-10	1.01E-09
SD11-1	191	995	1.26E-04	1.61E-06	4.23E-07	1.38E-07	2.12E-07	0.00E+00	4.77E-06	9.75E-10	1.00E-09
SD11-1	192	820	2.92E-06	1.44E-07	3.96E-08	9.92E-09	1.30E-08	3.20E-12	4.40E-07	9.11E-11	9.36E-11
SD11-1	193	821	2.42E-06	1.20E-07	3.28E-08	8.23E-09	1.08E-08	2.65E-12	3.65E-07	7.55E-11	7.76E-11
SD11-1	194	824	1.32E-06	6.50E-08	1.78E-08	4.47E-09	5.86E-09	1.44E-12	1.98E-07	4.10E-11	4.21E-11
SD11-1	195	995	1.25E-04	1.50E-06	4.25E-07	1.34E-07	1.90E-07	5.82E-11	4.46E-06	9.71E-10	9.97E-10

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD11-1	196	995	1.23E-04	1.43E-06	4.34E-07	1.34E-07	1.79E-07	0.00E+00	4.22E-06	9.83E-10	1.01E-09
SD11-1	197	995	1.22E-04	1.35E-06	4.33E-07	1.34E-07	1.60E-07	5.82E-11	4.00E-06	9.80E-10	1.00E-09
SD11-1	198	995	1.21E-04	1.28E-06	4.18E-07	1.34E-07	1.45E-07	0.00E+00	3.76E-06	9.52E-10	9.76E-10
SD11-1	199	995	1.20E-04	1.20E-06	4.02E-07	1.34E-07	1.27E-07	1.16E-10	3.52E-06	9.20E-10	9.44E-10
SD11-1	200	820	2.92E-06	1.09E-07	4.05E-08	1.00E-08	9.81E-09	3.10E-12	3.31E-07	9.10E-11	9.33E-11
SD11-1	201	821	2.42E-06	9.02E-08	3.36E-08	8.29E-09	8.14E-09	2.57E-12	2.75E-07	7.55E-11	7.74E-11
SD11-1	202	824	1.31E-06	4.90E-08	1.82E-08	4.50E-09	4.42E-09	1.40E-12	1.49E-07	4.10E-11	4.20E-11
SD11-1	203	995	1.19E-04	1.13E-06	4.00E-07	1.34E-07	1.23E-07	0.00E+00	3.29E-06	9.12E-10	9.35E-10
SD11-1	204	995	1.17E-04	1.07E-06	4.20E-07	1.34E-07	1.12E-07	5.82E-11	3.12E-06	9.39E-10	9.62E-10
SD11-1	205	995	1.16E-04	1.01E-06	4.30E-07	1.34E-07	1.04E-07	0.00E+00	2.95E-06	9.51E-10	9.73E-10
SD11-1	206	995	1.15E-04	9.63E-07	4.35E-07	1.34E-07	9.69E-08	0.00E+00	2.78E-06	9.55E-10	9.76E-10
SD11-1	207	995	1.37E-04	1.08E-06	5.28E-07	1.64E-07	1.12E-07	1.16E-10	3.12E-06	1.15E-09	1.17E-09
SD12	1	820	2.63E-05	3.10E-06	7.97E-08	2.68E-06	2.68E-06	3.71E-08	7.20E-07	6.27E-13	6.27E-13
SD12	2	821	2.18E-05	2.64E-06	6.91E-08	2.28E-06	2.29E-06	3.18E-08	6.11E-07	5.37E-13	5.37E-13
SD12	3	824	1.35E-05	1.62E-06	4.35E-08	1.41E-06	1.41E-06	1.98E-08	3.75E-07	3.34E-13	3.34E-13
SD12	4	27	1.77E-07	8.69E-12	1.32E-13	8.21E-12	7.90E-12	1.72E-13	2.15E-12	2.86E-18	2.86E-18
SD12	5	820	5.85E-05	1.34E-06	1.26E-08	1.37E-06	1.20E-06	4.35E-08	3.49E-07	1.04E-12	1.04E-12
SD12	6	821	4.85E-05	1.12E-06	1.06E-08	1.14E-06	1.00E-06	3.63E-08	2.92E-07	8.69E-13	8.70E-13
SD12	7	824	2.93E-05	6.67E-07	6.30E-09	6.78E-07	5.96E-07	2.19E-08	1.74E-07	5.20E-13	5.21E-13
SD12	8	27	2.52E-07	7.75E-12	1.14E-13	7.51E-12	7.05E-12	1.80E-13	1.93E-12	3.01E-18	3.01E-18
SD12	9	27	2.62E-07	5.24E-12	7.64E-14	5.31E-12	4.82E-12	1.33E-13	1.31E-12	2.34E-18	2.33E-18
SD12	10	27	3.11E-07	6.78E-12	8.49E-14	7.15E-12	6.63E-12	1.77E-13	1.73E-12	3.55E-18	3.47E-18
SD12	11	27	3.69E-07	6.53E-12	7.76E-14	7.47E-12	6.24E-12	1.80E-13	1.67E-12	3.94E-18	3.95E-18
SD12	12	27	4.23E-07	5.58E-12	6.07E-14	6.37E-12	4.89E-12	1.44E-13	1.43E-12	3.38E-18	3.38E-18
SD12	13	27	5.31E-07	4.70E-12	4.73E-14	5.35E-12	3.81E-12	1.13E-13	1.21E-12	2.70E-18	2.70E-18
SD12	14	820	6.77E-05	5.52E-07	1.44E-09	2.98E-07	3.32E-07	7.67E-09	1.46E-07	1.91E-13	1.91E-13
SD12	15	821	5.60E-05	4.63E-07	1.21E-09	2.51E-07	2.79E-07	6.44E-09	1.23E-07	1.61E-13	1.61E-13

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD12	16	824	3.43E-05	2.82E-07	7.35E-10	1.53E-07	1.70E-07	3.91E-09	7.48E-08	9.76E-14	9.76E-14
SD12	17	27	5.37E-07	3.07E-12	2.93E-14	3.66E-12	2.37E-12	7.07E-14	7.94E-13	1.70E-18	1.70E-18
SD12	18	27	5.70E-07	2.23E-12	1.98E-14	2.82E-12	1.63E-12	4.86E-14	5.79E-13	1.18E-18	1.18E-18
SD12	19	27	6.14E-07	1.88E-12	1.41E-14	2.42E-12	1.26E-12	3.63E-14	4.91E-13	8.90E-19	8.88E-19
SD12	20	27	6.60E-07	1.91E-12	1.08E-14	2.36E-12	1.22E-12	3.28E-14	5.00E-13	7.65E-19	7.07E-19
SD12	21	27	7.55E-07	2.38E-12	1.05E-14	2.90E-12	1.69E-12	4.14E-14	6.26E-13	9.07E-19	8.07E-19
SD12	22	27	8.30E-07	2.31E-12	8.77E-15	3.09E-12	1.64E-12	3.79E-14	6.08E-13	8.97E-19	8.62E-19
SD12	23	820	8.26E-05	1.31E-06	7.08E-09	1.22E-06	1.06E-06	3.39E-08	3.40E-07	8.40E-13	8.39E-13
SD12	24	821	6.85E-05	1.10E-06	5.98E-09	1.03E-06	8.97E-07	2.86E-08	2.86E-07	7.10E-13	7.09E-13
SD12	25	824	4.15E-05	6.67E-07	3.56E-09	6.14E-07	5.35E-07	1.72E-08	1.73E-07	4.27E-13	4.26E-13
SD12	26	27	8.18E-07	2.14E-12	6.79E-15	2.95E-12	1.39E-12	3.21E-14	5.64E-13	7.66E-19	7.39E-19
SD12	27	27	8.66E-07	2.30E-12	6.65E-15	3.21E-12	1.41E-12	3.48E-14	6.06E-13	8.72E-19	8.52E-19
SD12	28	27	9.15E-07	2.68E-12	8.13E-15	3.72E-12	1.66E-12	4.68E-14	7.09E-13	1.18E-18	1.18E-18
SD12	29	27	1.11E-06	3.88E-12	1.45E-14	5.34E-12	2.60E-12	8.70E-14	1.02E-12	2.15E-18	2.14E-18
SD12	30	27	1.02E-06	4.11E-12	2.26E-14	6.21E-12	3.32E-12	1.18E-13	1.07E-12	2.80E-18	2.71E-18
SD12	31	27	1.09E-06	4.06E-12	2.85E-14	7.20E-12	3.82E-12	1.18E-13	1.04E-12	2.85E-18	2.83E-18
SD12	32	820	6.14E-05	3.01E-07	2.96E-09	5.02E-07	3.39E-07	7.80E-09	7.31E-08	1.85E-13	1.85E-13
SD12	33	821	5.22E-05	2.54E-07	2.50E-09	4.24E-07	2.86E-07	6.58E-09	6.17E-08	1.56E-13	1.56E-13
SD12	34	824	3.27E-05	1.59E-07	1.56E-09	2.66E-07	1.78E-07	4.11E-09	3.86E-08	9.77E-14	9.76E-14
SD12	35	27	1.12E-06	3.43E-12	2.60E-14	6.93E-12	3.35E-12	9.76E-14	8.68E-13	2.34E-18	2.34E-18
SD12	36	27	1.15E-06	2.58E-12	2.02E-14	6.07E-12	2.56E-12	7.26E-14	6.50E-13	1.74E-18	1.73E-18
SD12	37	27	1.34E-06	2.04E-12	1.61E-14	5.82E-12	2.03E-12	5.70E-14	5.12E-13	1.37E-18	1.33E-18
SD12	38	27	1.19E-06	1.22E-12	9.72E-15	4.34E-12	1.22E-12	3.39E-14	3.06E-13	8.06E-19	7.91E-19
SD12	39	27	1.21E-06	8.63E-13	6.90E-15	3.81E-12	8.61E-13	2.38E-14	2.16E-13	5.56E-19	5.29E-19
SD12	40	27	1.25E-06	6.27E-13	5.05E-15	3.51E-12	6.28E-13	1.71E-14	1.56E-13	3.81E-19	3.73E-19
SD12	41	820	6.45E-05	4.26E-07	8.18E-08	3.40E-07	2.40E-07	4.63E-10	8.31E-09	1.67E-09	5.71E-11
SD12	42	821	5.49E-05	3.65E-07	7.01E-08	2.91E-07	2.04E-07	3.96E-10	7.11E-09	1.43E-09	4.89E-11

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD12	43	824	3.38E-05	2.24E-07	4.29E-08	1.79E-07	1.26E-07	2.45E-10	4.38E-09	8.76E-10	2.99E-11
SD12	44	27	1.27E-06	9.06E-13	7.67E-14	3.44E-12	4.74E-13	1.22E-14	1.13E-13	1.65E-15	4.66E-17
SD12	45	27	1.31E-06	1.64E-12	2.76E-13	3.99E-12	4.23E-13	8.55E-15	8.43E-14	5.78E-15	1.72E-16
SD12	46	27	1.34E-06	1.24E-12	2.20E-13	4.14E-12	3.45E-13	4.84E-15	5.08E-14	4.55E-15	1.43E-16
SD12	47	27	1.38E-06	8.55E-13	1.50E-13	4.29E-12	5.72E-13	2.77E-15	3.27E-14	3.06E-15	1.06E-16
SD12	48	27	1.41E-06	5.95E-13	1.06E-13	4.45E-12	7.39E-13	1.63E-15	2.39E-14	2.06E-15	8.38E-17
SD12	49	27	1.45E-06	4.13E-13	8.05E-14	4.56E-12	6.77E-13	9.74E-16	1.86E-14	1.36E-15	6.82E-17
SD12	50	820	7.23E-05	5.81E-08	2.58E-08	2.08E-07	1.41E-07	1.23E-11	7.19E-09	9.89E-11	2.02E-11
SD12	51	821	6.08E-05	4.91E-08	2.19E-08	1.76E-07	1.19E-07	1.04E-11	6.08E-09	8.36E-11	1.70E-11
SD12	52	824	3.75E-05	3.03E-08	1.35E-08	1.09E-07	7.34E-08	6.39E-12	3.75E-09	5.16E-11	1.05E-11
SD12	53	27	1.48E-06	2.94E-13	7.83E-14	4.63E-12	5.55E-13	6.02E-16	1.52E-14	9.17E-16	5.71E-17
SD12	54	27	1.51E-06	2.24E-13	8.24E-14	4.72E-12	4.62E-13	3.93E-16	1.38E-14	6.49E-16	5.18E-17
SD12	55	27	1.55E-06	1.82E-13	7.55E-14	4.82E-12	3.91E-13	2.63E-16	1.40E-14	4.71E-16	4.94E-17
SD12	56	27	1.58E-06	1.58E-13	6.39E-14	4.93E-12	3.37E-13	1.80E-16	1.56E-14	3.47E-16	4.81E-17
SD12	57	27	1.62E-06	1.51E-13	5.16E-14	5.04E-12	2.97E-13	1.27E-16	1.94E-14	2.61E-16	4.76E-17
SD12	58	27	1.66E-06	1.61E-13	4.03E-14	5.13E-12	2.66E-13	9.17E-17	2.64E-14	2.00E-16	4.74E-17
SD12	59	820	7.97E-05	1.79E-07	3.59E-09	1.54E-07	8.18E-08	1.24E-11	4.61E-08	2.61E-11	1.67E-11
SD12	60	821	6.61E-05	1.49E-07	2.99E-09	1.28E-07	6.82E-08	1.03E-11	3.84E-08	2.18E-11	1.39E-11
SD12	61	824	4.07E-05	9.16E-08	1.85E-09	7.90E-08	4.20E-08	6.36E-12	2.36E-08	1.34E-11	8.57E-12
SD12	62	27	1.69E-06	1.89E-13	3.06E-14	5.20E-12	2.43E-13	6.92E-17	3.74E-14	1.56E-16	4.66E-17
SD12	63	27	1.73E-06	2.37E-13	2.27E-14	5.26E-12	2.26E-13	5.64E-17	5.30E-14	1.23E-16	4.47E-17
SD12	64	27	1.76E-06	3.07E-13	1.67E-14	5.31E-12	2.15E-13	5.38E-17	7.43E-14	9.88E-17	4.28E-17
SD12	65	27	1.80E-06	3.94E-13	1.22E-14	5.35E-12	2.07E-13	5.83E-17	9.96E-14	8.14E-17	4.08E-17
SD12	66	27	1.83E-06	4.84E-13	8.70E-15	5.38E-12	1.97E-13	6.42E-17	1.26E-13	6.66E-17	3.79E-17
SD12	67	27	1.86E-06	5.80E-13	6.10E-15	5.40E-12	1.89E-13	6.61E-17	1.53E-13	5.51E-17	3.50E-17
SD12	68	820	8.45E-05	2.51E-07	3.04E-10	1.14E-07	8.05E-08	1.44E-11	6.74E-08	1.39E-11	1.28E-11
SD12	69	821	6.99E-05	2.09E-07	2.53E-10	9.43E-08	6.69E-08	1.20E-11	5.60E-08	1.16E-11	1.07E-11

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD12	70	824	4.25E-05	1.27E-07	1.54E-10	5.73E-08	4.06E-08	7.28E-12	3.41E-08	7.02E-12	6.48E-12
SD12	71	27	1.90E-06	6.82E-13	4.28E-15	5.43E-12	1.83E-13	6.57E-17	1.82E-13	4.71E-17	3.29E-17
SD12	72	27	1.93E-06	7.71E-13	3.09E-15	5.46E-12	1.83E-13	6.18E-17	2.07E-13	4.21E-17	3.18E-17
SD12	73	27	1.96E-06	7.31E-13	2.20E-15	5.49E-12	1.80E-13	5.53E-17	1.97E-13	3.79E-17	3.05E-17
SD12	74	27	2.00E-06	6.32E-13	1.61E-15	5.54E-12	1.90E-13	4.92E-17	1.69E-13	3.66E-17	3.10E-17
SD12	75	27	2.03E-06	5.41E-13	1.26E-15	5.60E-12	2.16E-13	4.53E-17	1.44E-13	3.88E-17	3.43E-17
SD12	76	27	2.06E-06	4.68E-13	1.07E-15	5.68E-12	2.56E-13	4.21E-17	1.23E-13	4.36E-17	3.97E-17
SD12	77	820	8.92E-05	9.69E-08	3.35E-10	2.03E-07	1.83E-07	9.11E-12	2.29E-08	3.00E-11	2.88E-11
SD12	78	821	7.37E-05	8.02E-08	2.77E-10	1.68E-07	1.51E-07	7.53E-12	1.90E-08	2.48E-11	2.38E-11
SD12	79	824	4.42E-05	4.80E-08	1.66E-10	1.01E-07	9.05E-08	4.52E-12	1.14E-08	1.49E-11	1.43E-11
SD12	80	27	2.09E-06	4.10E-13	9.68E-16	5.76E-12	3.03E-13	4.01E-17	1.06E-13	5.00E-17	4.64E-17
SD12	81	27	2.13E-06	3.63E-13	9.27E-16	5.84E-12	3.54E-13	3.82E-17	9.24E-14	5.74E-17	5.39E-17
SD12	82	27	2.16E-06	3.25E-13	9.25E-16	5.92E-12	4.02E-13	4.25E-17	8.10E-14	6.52E-17	6.17E-17
SD12	83	27	2.19E-06	2.93E-13	9.35E-16	5.99E-12	4.47E-13	4.16E-17	7.12E-14	7.30E-17	6.96E-17
SD12	84	27	2.22E-06	2.65E-13	9.56E-16	6.06E-12	4.86E-13	4.01E-17	6.29E-14	8.08E-17	7.73E-17
SD12	85	27	2.25E-06	2.41E-13	9.80E-16	6.12E-12	5.21E-13	3.84E-17	5.57E-14	8.84E-17	8.49E-17
SD12	86	820	8.27E-05	6.35E-08	1.32E-09	2.11E-07	2.05E-07	1.07E-10	1.24E-08	5.12E-11	3.64E-11
SD12	87	821	6.93E-05	5.40E-08	1.19E-09	1.78E-07	1.72E-07	9.82E-11	1.06E-08	4.40E-11	3.05E-11
SD12	88	824	4.15E-05	3.26E-08	7.32E-10	1.07E-07	1.03E-07	6.12E-11	6.36E-09	2.67E-11	1.83E-11
SD12	89	27	2.28E-06	2.21E-13	1.01E-15	6.17E-12	5.54E-13	3.71E-17	4.96E-14	9.60E-17	9.24E-17
SD12	90	27	2.31E-06	2.04E-13	1.04E-15	6.22E-12	5.86E-13	3.56E-17	4.45E-14	1.04E-16	9.99E-17
SD12	91	27	2.34E-06	1.95E-13	1.58E-15	6.32E-12	6.16E-13	9.02E-17	4.11E-14	1.18E-16	1.07E-16
SD12	92	27	2.37E-06	1.90E-13	3.85E-15	6.17E-12	5.60E-13	3.37E-16	3.84E-14	1.41E-16	9.78E-17
SD12	93	27	2.35E-06	1.63E-13	4.36E-15	5.52E-12	4.62E-13	4.00E-16	3.21E-14	1.34E-16	8.14E-17
SD12	94	27	2.31E-06	1.32E-13	4.05E-15	4.76E-12	3.75E-13	3.78E-16	2.56E-14	1.17E-16	6.71E-17
SD12	95	820	4.12E-05	2.81E-08	1.29E-09	1.06E-07	1.06E-07	1.17E-10	4.55E-09	3.81E-11	2.21E-11
SD12	96	821	3.52E-05	2.40E-08	1.10E-09	9.04E-08	9.04E-08	9.99E-11	3.89E-09	3.26E-11	1.89E-11

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD12	97	824	2.19E-05	1.50E-08	6.88E-10	5.64E-08	5.64E-08	6.23E-11	2.42E-09	2.03E-11	1.18E-11
SD12	98	27	2.28E-06	1.07E-13	3.59E-15	4.08E-12	3.09E-13	3.38E-16	2.03E-14	1.01E-16	5.65E-17
SD12	99	27	2.24E-06	8.79E-14	3.16E-15	3.53E-12	2.64E-13	2.98E-16	1.63E-14	8.86E-17	4.94E-17
SD12	100	27	2.20E-06	7.43E-14	2.82E-15	3.10E-12	2.35E-13	2.65E-16	1.34E-14	8.03E-17	4.53E-17
SD12	101	27	2.17E-06	6.48E-14	2.57E-15	2.79E-12	2.20E-13	2.40E-16	1.13E-14	7.54E-17	4.37E-17
SD12	102	27	2.14E-06	5.86E-14	2.40E-15	2.57E-12	2.14E-13	2.22E-16	9.89E-15	7.33E-17	4.39E-17
SD12	103	27	2.12E-06	5.46E-14	2.28E-15	2.43E-12	2.16E-13	2.09E-16	8.90E-15	7.31E-17	4.55E-17
SD12	104	820	4.51E-05	2.27E-08	9.60E-10	1.19E-07	1.24E-07	7.83E-11	3.04E-09	4.03E-11	2.94E-11
SD12	105	821	3.85E-05	1.94E-08	8.20E-10	1.02E-07	1.06E-07	6.68E-11	2.60E-09	3.45E-11	2.52E-11
SD12	106	824	2.40E-05	1.21E-08	5.11E-10	6.37E-08	6.63E-08	4.16E-11	1.62E-09	2.15E-11	1.57E-11
SD12	107	27	2.09E-06	5.20E-14	2.20E-15	2.35E-12	2.21E-13	1.98E-16	8.16E-15	7.42E-17	4.79E-17
SD12	108	27	2.07E-06	4.99E-14	2.11E-15	2.32E-12	2.27E-13	1.88E-16	7.54E-15	7.54E-17	5.04E-17
SD12	109	27	2.05E-06	4.84E-14	2.05E-15	2.32E-12	2.34E-13	1.78E-16	7.06E-15	7.71E-17	5.33E-17
SD12	110	27	2.04E-06	4.78E-14	2.01E-15	2.36E-12	2.45E-13	1.73E-16	6.72E-15	8.00E-17	5.69E-17
SD12	111	27	2.02E-06	4.76E-14	1.98E-15	2.42E-12	2.57E-13	1.67E-16	6.45E-15	8.34E-17	6.10E-17
SD12	112	27	2.01E-06	4.77E-14	1.96E-15	2.50E-12	2.70E-13	1.62E-16	6.22E-15	8.71E-17	6.53E-17
SD12	113	820	5.14E-05	1.95E-08	7.49E-10	1.27E-07	1.34E-07	5.35E-11	2.08E-09	4.27E-11	3.51E-11
SD12	114	821	4.39E-05	1.67E-08	6.39E-10	1.09E-07	1.15E-07	4.57E-11	1.77E-09	3.65E-11	3.00E-11
SD12	115	824	2.73E-05	1.04E-08	3.97E-10	6.75E-08	7.11E-08	2.84E-11	1.10E-09	2.27E-11	1.86E-11
SD12	116	27	2.00E-06	4.79E-14	1.94E-15	2.60E-12	2.84E-13	1.58E-16	6.02E-15	9.11E-17	6.99E-17
SD12	117	27	2.04E-06	4.92E-14	1.97E-15	2.76E-12	3.04E-13	1.57E-16	5.96E-15	9.72E-17	7.61E-17
SD12	118	27	1.84E-06	4.44E-14	1.75E-15	2.59E-12	2.85E-13	1.37E-16	5.18E-15	9.07E-17	7.22E-17
SD12	119	27	2.21E-06	5.24E-14	2.03E-15	3.25E-12	3.47E-13	1.56E-16	5.86E-15	1.10E-16	8.95E-17
SD12	120	27	1.94E-06	4.53E-14	1.73E-15	2.96E-12	3.09E-13	1.30E-16	4.86E-15	9.84E-17	8.10E-17
SD12	121	27	2.21E-06	5.17E-14	1.93E-15	3.53E-12	3.62E-13	1.42E-16	5.30E-15	1.16E-16	9.67E-17
SD12	122	820	5.76E-05	1.62E-08	5.46E-10	1.19E-07	1.24E-07	3.28E-11	1.27E-09	4.05E-11	3.58E-11
SD12	123	821	4.92E-05	1.38E-08	4.66E-10	1.01E-07	1.05E-07	2.80E-11	1.09E-09	3.46E-11	3.06E-11

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD12	124	824	3.05E-05	8.57E-09	2.89E-10	6.29E-08	6.54E-08	1.74E-11	6.75E-10	2.15E-11	1.90E-11
SD12	125	27	2.22E-06	5.14E-14	1.88E-15	3.68E-12	3.68E-13	1.34E-16	5.00E-15	1.18E-16	1.00E-16
SD12	126	27	1.11E-06	2.52E-14	9.04E-16	1.90E-12	1.83E-13	6.33E-17	2.36E-15	5.90E-17	5.04E-17
SD12	127	27	2.23E-06	4.89E-14	1.73E-15	3.91E-12	3.61E-13	1.19E-16	4.40E-15	1.17E-16	1.01E-16
SD12	128	27	2.24E-06	4.76E-14	1.64E-15	4.06E-12	3.56E-13	1.09E-16	4.03E-15	1.16E-16	1.01E-16
SD12	129	27	2.25E-06	4.70E-14	1.57E-15	4.23E-12	3.55E-13	1.02E-16	3.73E-15	1.17E-16	1.03E-16
SD12	130	27	1.70E-06	3.52E-14	1.15E-15	3.27E-12	2.67E-13	7.22E-17	2.63E-15	8.87E-17	7.91E-17
SD12	131	820	6.25E-05	1.49E-08	4.29E-10	1.13E-07	1.15E-07	1.99E-11	7.72E-10	4.01E-11	3.71E-11
SD12	132	821	5.34E-05	1.27E-08	3.66E-10	9.66E-08	9.84E-08	1.70E-11	6.59E-10	3.42E-11	3.17E-11
SD12	133	824	3.30E-05	7.87E-09	2.27E-10	5.98E-08	6.09E-08	1.05E-11	4.08E-10	2.12E-11	1.96E-11
SD12	134	27	1.99E-06	4.10E-14	1.31E-15	3.92E-12	3.13E-13	7.91E-17	2.90E-15	1.05E-16	9.42E-17
SD12	135	27	2.01E-06	4.10E-14	1.28E-15	4.02E-12	3.14E-13	7.50E-17	2.72E-15	1.06E-16	9.61E-17
SD12	136	27	2.31E-06	4.69E-14	1.42E-15	4.69E-12	3.61E-13	8.02E-17	2.92E-15	1.23E-16	1.12E-16
SD12	137	27	2.32E-06	4.71E-14	1.39E-15	4.79E-12	3.62E-13	7.61E-17	2.71E-15	1.25E-16	1.15E-16
SD12	138	27	2.34E-06	4.74E-14	1.36E-15	4.88E-12	3.63E-13	7.13E-17	2.55E-15	1.26E-16	1.17E-16
SD12	139	27	1.18E-06	2.40E-14	6.73E-16	2.47E-12	1.82E-13	3.66E-17	1.24E-15	6.37E-17	5.92E-17
SD12	140	820	6.05E-05	1.42E-08	3.62E-10	1.04E-07	1.05E-07	1.24E-11	4.81E-10	3.85E-11	3.66E-11
SD12	141	821	5.16E-05	1.21E-08	3.09E-10	8.90E-08	8.94E-08	1.06E-11	4.10E-10	3.29E-11	3.13E-11
SD12	142	824	3.19E-05	7.47E-09	1.91E-10	5.50E-08	5.53E-08	6.54E-12	2.54E-10	2.03E-11	1.93E-11
SD12	143	27	2.37E-06	4.82E-14	1.33E-15	4.99E-12	3.64E-13	6.92E-17	2.35E-15	1.29E-16	1.20E-16
SD12	144	27	2.38E-06	4.86E-14	1.31E-15	5.06E-12	3.64E-13	6.53E-17	2.19E-15	1.30E-16	1.22E-16
SD12	145	27	2.40E-06	4.90E-14	1.29E-15	5.12E-12	3.64E-13	6.14E-17	2.05E-15	1.31E-16	1.24E-16
SD12	146	27	2.42E-06	4.94E-14	1.28E-15	5.18E-12	3.63E-13	5.83E-17	1.92E-15	1.32E-16	1.25E-16
SD12	147	27	1.22E-06	2.48E-14	6.34E-16	2.61E-12	1.81E-13	2.73E-17	9.09E-16	6.66E-17	6.33E-17
SD12	148	27	2.45E-06	4.99E-14	1.26E-15	5.27E-12	3.62E-13	5.23E-17	1.73E-15	1.34E-16	1.28E-16
SD12	149	820	7.04E-05	1.64E-08	4.00E-10	1.14E-07	1.13E-07	1.02E-11	3.80E-10	4.42E-11	4.26E-11
SD12	150	821	5.98E-05	1.39E-08	3.40E-10	9.73E-08	9.63E-08	8.68E-12	3.23E-10	3.75E-11	3.62E-11

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD12	151	824	3.69E-05	8.60E-09	2.10E-10	6.01E-08	5.95E-08	5.37E-12	2.00E-10	2.32E-11	2.24E-11
SD12	152	27	2.46E-06	5.03E-14	1.26E-15	5.32E-12	3.61E-13	4.92E-17	1.61E-15	1.35E-16	1.29E-16
SD12	153	27	2.48E-06	5.08E-14	1.25E-15	5.37E-12	3.59E-13	4.68E-17	1.52E-15	1.36E-16	1.30E-16
SD12	154	27	2.50E-06	5.12E-14	1.26E-15	5.42E-12	3.57E-13	4.49E-17	1.44E-15	1.37E-16	1.32E-16
SD12	155	27	1.26E-06	2.57E-14	6.30E-16	2.73E-12	1.78E-13	2.17E-17	6.83E-16	6.87E-17	6.62E-17
SD12	156	27	2.53E-06	5.18E-14	1.27E-15	5.49E-12	3.55E-13	4.32E-17	1.34E-15	1.38E-16	1.33E-16
SD12	157	27	2.55E-06	5.22E-14	1.28E-15	5.53E-12	3.53E-13	4.25E-17	1.28E-15	1.39E-16	1.34E-16
SD12	158	820	3.24E-05	9.58E-09	3.55E-10	5.09E-08	4.94E-08	2.85E-11	6.87E-10	2.12E-11	1.80E-11
SD12	159	821	2.76E-05	8.81E-09	3.41E-10	4.49E-08	4.37E-08	2.93E-11	6.95E-10	1.89E-11	1.57E-11
SD12	160	824	1.67E-05	5.40E-09	2.10E-10	2.74E-08	2.67E-08	1.81E-11	4.30E-10	1.16E-11	9.58E-12
SD12	161	27	2.58E-06	5.68E-14	1.67E-15	5.65E-12	3.47E-13	9.80E-17	2.45E-15	1.41E-16	1.30E-16
SD12	162	27	2.56E-06	5.03E-14	1.80E-15	5.00E-12	2.67E-13	1.49E-16	3.52E-15	1.12E-16	9.67E-17
SD12	163	27	1.25E-06	1.82E-14	6.58E-16	2.01E-12	9.58E-14	5.59E-17	1.31E-15	4.04E-17	3.46E-17
SD12	164	27	2.43E-06	2.61E-14	9.43E-16	3.22E-12	1.37E-13	8.13E-17	1.89E-15	5.77E-17	4.94E-17
SD12	165	27	2.36E-06	1.66E-14	6.00E-16	2.39E-12	8.68E-14	5.33E-17	1.22E-15	3.66E-17	3.13E-17
SD12	166	27	2.29E-06	1.06E-14	3.82E-16	1.77E-12	5.50E-14	3.58E-17	7.91E-16	2.31E-17	1.98E-17
SD12	167	27	2.23E-06	6.79E-15	2.42E-16	1.31E-12	3.48E-14	2.36E-17	5.24E-16	1.46E-17	1.25E-17
SD12	168	27	1.09E-06	2.39E-15	8.61E-17	5.25E-13	1.22E-14	9.11E-18	1.84E-16	5.14E-18	4.38E-18
SD12	169	27	2.14E-06	3.50E-15	1.24E-16	8.43E-13	1.75E-14	1.37E-17	2.84E-16	7.32E-18	6.23E-18
SD12	170	27	2.08E-06	2.25E-15	7.91E-17	6.29E-13	1.10E-14	9.76E-18	1.94E-16	4.61E-18	3.90E-18
SD12	171	27	2.02E-06	1.47E-15	5.14E-17	4.70E-13	6.98E-15	7.59E-18	1.35E-16	2.91E-18	2.44E-18
SD12	172	27	1.97E-06	9.99E-16	3.34E-17	3.52E-13	4.47E-15	5.64E-18	1.01E-16	1.83E-18	1.53E-18
SD12	173	27	9.66E-07	3.75E-16	1.21E-17	1.41E-13	1.55E-15	2.39E-18	3.82E-17	6.47E-19	5.37E-19
SD12	174	27	1.89E-06	5.83E-16	1.82E-17	2.29E-13	2.29E-15	4.55E-18	7.29E-17	9.22E-19	7.61E-19
SD12	175	27	1.85E-06	4.02E-16	1.26E-17	1.72E-13	1.48E-15	3.47E-18	5.55E-17	5.90E-19	4.78E-19
SD12	176	27	1.80E-06	3.19E-16	9.54E-18	1.30E-13	9.85E-16	3.69E-18	4.86E-17	3.76E-19	2.72E-19
SD12	177	27	1.75E-06	2.36E-16	6.94E-18	9.83E-14	6.66E-16	3.04E-18	4.51E-17	2.44E-19	1.67E-19

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD12	178	27	8.59E-07	1.39E-16	2.82E-18	3.99E-14	2.64E-16	1.95E-18	2.08E-17	8.81E-20	5.84E-20
SD12	179	820	3.23E-06	6.05E-10	2.38E-11	3.09E-09	3.10E-09	1.01E-12	2.38E-11	1.56E-12	1.45E-12
SD12	180	821	2.19E-06	4.10E-10	1.61E-11	2.09E-09	2.10E-09	6.89E-13	1.59E-11	1.06E-12	9.83E-13
SD12	181	824	9.03E-07	1.68E-10	6.64E-12	8.61E-10	8.65E-10	2.84E-13	6.54E-12	4.35E-13	4.04E-13
SD12	182	27	1.69E-06	1.94E-16	4.99E-18	6.51E-14	4.02E-16	3.04E-18	4.16E-17	1.30E-19	8.22E-20
SD12	183	27	1.64E-06	1.94E-16	4.55E-18	4.95E-14	3.05E-16	3.04E-18	3.82E-17	9.15E-20	5.04E-20
SD12	184	27	1.60E-06	2.08E-16	5.64E-18	4.20E-14	4.86E-16	2.39E-18	3.82E-17	1.85E-19	1.39E-19
SD12	185	27	1.56E-06	5.83E-16	2.06E-17	6.71E-14	2.33E-15	3.69E-18	5.55E-17	1.12E-18	9.97E-19
SD12	186	27	7.67E-07	5.27E-16	1.91E-17	5.45E-14	2.39E-15	2.17E-18	3.47E-17	1.17E-18	1.07E-18
SD12	187	27	1.51E-06	1.65E-15	6.22E-17	1.67E-13	7.90E-15	5.64E-18	9.37E-17	3.92E-18	3.61E-18
SD12	188	820	2.85E-05	5.09E-09	1.95E-10	2.57E-08	2.63E-08	6.41E-12	1.50E-10	1.32E-11	1.25E-11
SD12	189	821	2.29E-05	4.10E-09	1.57E-10	2.07E-08	2.11E-08	5.12E-12	1.20E-10	1.06E-11	1.01E-11
SD12	190	824	1.07E-05	1.90E-09	7.29E-11	9.61E-09	9.82E-09	2.36E-12	5.54E-11	4.94E-12	4.68E-12
SD12	191	27	1.48E-06	2.60E-15	9.76E-17	2.64E-13	1.26E-14	6.94E-18	1.25E-16	6.30E-18	5.86E-18
SD12	192	27	1.46E-06	3.61E-15	1.37E-16	3.77E-13	1.78E-14	7.59E-18	1.49E-16	8.91E-18	8.33E-18
SD12	193	27	1.43E-06	4.65E-15	1.76E-16	5.03E-13	2.33E-14	9.11E-18	1.80E-16	1.16E-17	1.09E-17
SD12	194	27	7.09E-07	2.73E-15	1.03E-16	3.02E-13	1.38E-14	4.99E-18	9.71E-17	6.88E-18	6.49E-18
SD12	195	27	1.40E-06	6.29E-15	2.38E-16	7.11E-13	3.17E-14	1.06E-17	2.15E-16	1.59E-17	1.50E-17
SD12	196	27	1.39E-06	7.37E-15	2.78E-16	8.57E-13	3.74E-14	1.13E-17	2.29E-16	1.87E-17	1.78E-17
SD12	197	820	3.42E-05	5.78E-09	2.20E-10	2.88E-08	3.02E-08	5.06E-12	1.19E-10	1.51E-11	1.45E-11
SD12	198	821	2.92E-05	4.93E-09	1.87E-10	2.46E-08	2.58E-08	4.31E-12	1.01E-10	1.28E-11	1.24E-11
SD12	199	824	1.77E-05	2.98E-09	1.13E-10	1.49E-08	1.56E-08	2.60E-12	6.09E-11	7.77E-12	7.49E-12
SD12	200	27	1.38E-06	8.44E-15	3.18E-16	1.01E-12	4.30E-14	1.19E-17	2.46E-16	2.15E-17	2.05E-17
SD12	201	27	1.37E-06	9.49E-15	3.57E-16	1.16E-12	4.85E-14	1.28E-17	2.57E-16	2.42E-17	2.32E-17
SD12	202	27	6.81E-07	5.11E-15	1.93E-16	6.38E-13	2.63E-14	6.29E-18	1.32E-16	1.31E-17	1.26E-17
SD12	203	27	1.63E-06	1.33E-14	5.02E-16	1.69E-12	6.86E-14	1.58E-17	3.23E-16	3.41E-17	3.28E-17
SD13	1	9609	8.34E-02	6.55E-02	4.17E-03	4.81E-02	4.58E-02	2.00E-04	1.22E-02	3.65E-09	3.65E-09

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD13	2	9609	3.10E-01	2.43E-01	3.44E-03	2.39E-01	2.20E-01	3.16E-03	5.94E-02	5.24E-08	5.23E-08
SD13	3	9609	2.27E-01	1.68E-01	1.89E-03	1.86E-01	1.97E-01	5.96E-03	4.23E-02	9.66E-08	9.66E-08
SD13	4	9609	1.57E-01	1.16E-01	1.37E-03	1.19E-01	1.29E-01	5.41E-03	2.98E-02	9.60E-08	9.70E-08
SD13	5	9609	9.50E-02	8.02E-02	7.04E-04	7.45E-02	7.96E-02	3.12E-03	2.07E-02	6.13E-08	6.14E-08
SD13	6	9609	6.57E-02	5.65E-02	6.40E-04	5.95E-02	6.26E-02	3.27E-03	1.45E-02	6.24E-08	6.24E-08
SD13	7	9609	3.23E-02	3.05E-02	6.63E-04	3.90E-02	3.88E-02	2.96E-03	7.73E-03	5.74E-08	5.76E-08
SD13	8	9599	1.64E-03	1.49E-03	3.02E-05	1.76E-03	1.78E-03	1.55E-04	3.82E-04	2.99E-09	3.00E-09
SD13	9	9609	1.01E-02	9.76E-03	2.29E-04	1.34E-02	1.28E-02	9.10E-04	2.42E-03	1.82E-08	1.82E-08
SD13	10	9599	2.16E-04	1.64E-04	3.84E-04	1.58E-04	1.25E-04	7.75E-06	2.08E-05	6.28E-05	1.02E-06
SD13	11	9609	9.73E-03	7.19E-03	3.34E-02	1.14E-02	6.46E-03	3.23E-04	8.75E-04	5.04E-03	9.82E-05
SD13	12	9599	1.18E-03	8.93E-04	5.17E-03	1.59E-03	8.00E-04	3.47E-05	9.46E-05	7.74E-04	1.54E-05
SD13	13	9609	4.21E-03	2.26E-03	1.30E-02	5.08E-03	2.68E-03	7.98E-05	2.30E-04	1.87E-03	3.94E-05
SD13	14	9599	7.34E-06	4.28E-06	2.44E-05	9.46E-06	4.94E-06	1.53E-07	4.31E-07	3.58E-06	7.51E-08
SD13	15	9609	1.65E-03	6.93E-04	4.96E-03	1.57E-03	8.76E-04	1.84E-05	9.04E-05	4.29E-04	9.43E-06
SD13	16	9609	4.35E-04	2.26E-04	1.14E-03	6.59E-04	3.05E-04	3.45E-06	3.33E-05	8.09E-05	1.98E-06
SD13	17	9609	1.53E-04	1.43E-04	3.15E-04	6.41E-04	2.02E-04	9.29E-07	1.96E-05	2.20E-05	6.99E-07
SD13	18	9609	6.19E-05	1.29E-04	9.23E-05	8.16E-04	1.98E-04	2.57E-07	1.59E-05	6.28E-06	3.56E-07
SD13	19	9609	3.12E-05	1.30E-04	2.91E-05	9.47E-04	2.25E-04	7.08E-08	1.42E-05	1.94E-06	2.58E-07
SD13	20	9609	2.21E-05	1.38E-04	1.24E-05	9.91E-04	2.99E-04	2.42E-08	1.16E-05	7.96E-07	2.59E-07
SD13	21	9609	1.39E-05	1.16E-04	5.74E-06	6.41E-04	2.85E-04	7.45E-09	5.80E-06	3.58E-07	2.13E-07
SD13	22	9609	1.13E-05	1.32E-04	4.32E-06	5.19E-04	2.25E-04	0.00E+00	4.16E-06	2.67E-07	2.05E-07
SD13	23	9609	9.60E-06	1.07E-04	4.25E-06	4.97E-04	1.72E-04	0.00E+00	3.37E-06	2.30E-07	1.97E-07
SD13	24	9609	8.40E-06	9.17E-05	4.76E-06	4.63E-04	1.57E-04	5.59E-09	2.85E-06	2.11E-07	1.89E-07
SD13	25	9609	7.81E-06	9.24E-05	6.52E-06	5.71E-04	1.77E-04	0.00E+00	2.80E-06	2.24E-07	2.05E-07
SD13	26	9609	5.72E-06	6.96E-05	7.00E-06	5.00E-04	1.60E-04	0.00E+00	2.16E-06	1.84E-07	1.71E-07
SD13	27	9609	4.71E-06	6.86E-05	8.64E-06	4.28E-04	1.69E-04	0.00E+00	1.95E-06	1.73E-07	1.61E-07
SD13	28	9609	3.76E-06	6.99E-05	8.30E-06	3.03E-04	1.82E-04	0.00E+00	1.83E-06	1.62E-07	1.51E-07

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD13	29	9609	3.16E-06	8.08E-05	4.35E-06	2.58E-04	2.03E-04	0.00E+00	1.76E-06	1.51E-07	1.43E-07
SD13	30	9609	2.80E-06	1.12E-04	3.08E-06	3.17E-04	2.72E-04	0.00E+00	2.01E-06	1.63E-07	1.54E-07
SD13	31	9609	2.03E-06	8.80E-05	2.35E-06	3.19E-04	2.50E-04	0.00E+00	1.82E-06	1.37E-07	1.29E-07
SD13	32	9609	1.55E-06	4.93E-05	2.35E-06	3.67E-04	2.28E-04	0.00E+00	1.89E-06	1.29E-07	1.24E-07
SD13	33	9609	1.31E-06	4.18E-05	2.42E-06	4.21E-04	2.34E-04	0.00E+00	2.07E-06	1.26E-07	1.19E-07
SD13	34	9609	1.01E-06	4.38E-05	2.56E-06	4.83E-04	2.50E-04	0.00E+00	2.28E-06	1.19E-07	1.15E-07
SD13	35	9609	1.01E-06	5.13E-05	3.34E-06	5.67E-04	3.12E-04	0.00E+00	2.91E-06	1.33E-07	1.26E-07
SD13	36	9609	6.56E-07	3.39E-05	3.17E-06	3.28E-04	2.83E-04	0.00E+00	2.94E-06	1.11E-07	1.07E-07
SD13	37	9609	7.15E-07	2.94E-05	3.50E-06	2.32E-04	2.95E-04	2.42E-08	3.56E-06	1.15E-07	1.04E-07
SD13	38	9609	8.94E-07	3.26E-05	3.83E-06	2.36E-04	3.16E-04	4.66E-08	4.34E-06	1.16E-07	1.01E-07
SD13	39	9609	1.31E-06	4.04E-05	4.14E-06	2.78E-04	3.43E-04	1.08E-07	5.65E-06	1.27E-07	9.89E-08
SD13	40	9609	2.50E-06	6.29E-05	5.44E-06	3.94E-04	4.37E-04	3.32E-07	9.46E-06	1.93E-07	1.10E-07
SD13	41	9609	2.98E-06	7.97E-05	6.21E-06	4.21E-04	4.29E-04	7.97E-07	1.34E-05	2.85E-07	9.47E-08
SD13	42	9609	1.13E-06	6.49E-05	6.01E-06	4.51E-04	4.19E-04	3.11E-07	8.88E-06	1.63E-07	8.91E-08
SD13	43	9609	3.58E-07	4.86E-05	1.91E-05	2.82E-04	4.34E-04	8.01E-08	7.82E-06	1.06E-07	8.65E-08
SD13	44	9609	5.96E-08	3.65E-05	2.90E-05	8.77E-05	4.65E-04	2.05E-08	8.36E-06	9.13E-08	8.43E-08
SD13	45	9609	1.19E-07	4.07E-05	4.03E-05	2.84E-05	5.77E-04	7.45E-09	1.07E-05	9.59E-08	9.38E-08
SD13	46	9609	0.00E+00	3.84E-05	4.08E-05	9.12E-06	5.47E-04	1.86E-09	1.05E-05	8.01E-08	7.99E-08
SD13	47	9609	1.19E-07	4.23E-05	4.60E-05	5.54E-06	5.88E-04	0.00E+00	1.15E-05	7.87E-08	7.80E-08
SD13	48	9609	0.00E+00	4.63E-05	5.14E-05	4.35E-06	6.28E-04	3.73E-09	1.27E-05	7.64E-08	7.61E-08
SD13	49	9609	0.00E+00	5.08E-05	5.70E-05	3.93E-06	6.65E-04	1.86E-09	1.40E-05	7.40E-08	7.43E-08
SD13	50	9609	0.00E+00	6.41E-05	7.25E-05	4.29E-06	7.84E-04	0.00E+00	1.77E-05	8.29E-08	8.26E-08
SD13	51	9609	0.00E+00	6.49E-04	9.65E-05	6.27E-04	1.08E-03	1.72E-05	1.56E-04	4.22E-06	1.40E-07
SD13	52	9609	1.19E-07	2.27E-04	7.74E-05	1.90E-04	6.06E-04	5.14E-06	5.59E-05	1.30E-06	7.79E-08
SD13	53	9609	0.00E+00	1.09E-04	9.15E-05	4.85E-05	5.13E-04	1.25E-06	2.84E-05	3.64E-07	6.86E-08
SD13	54	9609	0.00E+00	9.09E-05	1.10E-04	1.47E-05	4.98E-04	3.07E-07	2.46E-05	1.44E-07	6.91E-08
SD13	55	9609	2.38E-07	1.20E-04	1.20E-04	1.25E-05	4.24E-04	2.05E-07	3.27E-05	7.50E-08	5.84E-08

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD13	56	9609	1.19E-07	1.18E-04	1.59E-04	7.09E-06	4.31E-04	1.02E-07	3.24E-05	7.64E-08	7.09E-08
SD13	57	9609	0.00E+00	8.92E-05	1.37E-04	3.10E-06	2.77E-04	1.49E-08	2.46E-05	5.77E-08	5.55E-08
SD13	58	9609	0.00E+00	1.14E-04	1.90E-04	3.04E-06	3.18E-04	1.12E-08	3.16E-05	6.94E-08	6.79E-08
SD13	59	9609	0.00E+00	9.39E-05	1.43E-04	2.27E-06	2.64E-04	0.00E+00	2.59E-05	5.31E-08	5.31E-08
SD13	60	9609	1.19E-07	1.19E-04	1.35E-04	2.62E-06	3.54E-04	0.00E+00	3.27E-05	6.66E-08	6.50E-08
SD13	61	9609	0.00E+00	9.40E-05	4.58E-05	1.97E-06	3.06E-04	0.00E+00	2.59E-05	5.08E-08	5.09E-08
SD13	62	9609	0.00E+00	1.16E-04	3.85E-05	2.38E-06	4.14E-04	0.00E+00	3.21E-05	6.38E-08	6.23E-08
SD13	63	9609	0.00E+00	1.30E-04	3.35E-05	2.62E-06	3.60E-04	4.10E-08	3.60E-05	5.22E-08	5.09E-08
SD13	64	9609	5.96E-08	1.29E-04	3.61E-05	3.83E-05	3.27E-04	3.54E-08	3.49E-05	5.77E-08	5.68E-08
SD13	65	9609	0.00E+00	8.89E-05	2.84E-05	7.03E-05	1.97E-04	1.12E-08	2.32E-05	4.52E-08	4.46E-08
SD13	66	9609	0.00E+00	4.79E-05	3.77E-05	2.25E-05	2.38E-04	0.00E+00	1.28E-05	5.54E-08	5.54E-08
SD13	67	9609	0.00E+00	1.44E-05	4.01E-05	5.78E-06	1.78E-04	5.59E-09	3.83E-06	5.59E-08	5.50E-08
SD13	68	9609	0.00E+00	5.36E-06	3.37E-05	2.15E-06	1.24E-04	0.00E+00	1.46E-06	4.38E-08	4.36E-08
SD13	69	9609	0.00E+00	3.87E-06	3.51E-05	1.67E-06	1.25E-04	0.00E+00	1.03E-06	4.33E-08	4.32E-08
SD13	70	9609	0.00E+00	4.23E-06	4.61E-05	1.79E-06	1.62E-04	0.00E+00	1.13E-06	5.40E-08	5.35E-08
SD13	71	9609	1.19E-07	3.28E-06	3.96E-05	1.37E-06	1.36E-04	0.00E+00	8.79E-07	4.24E-08	4.24E-08
SD13	72	9609	0.00E+00	4.17E-06	5.34E-05	1.61E-06	1.78E-04	0.00E+00	1.12E-06	5.31E-08	5.24E-08
SD13	73	9609	0.00E+00	3.58E-06	2.68E-05	1.31E-06	1.49E-04	0.00E+00	9.83E-07	4.14E-08	4.15E-08
SD13	74	9609	0.00E+00	4.59E-06	1.40E-05	1.61E-06	1.94E-04	0.00E+00	1.22E-06	5.12E-08	5.15E-08
SD13	75	9609	0.00E+00	3.52E-06	7.82E-06	1.19E-06	1.62E-04	0.00E+00	9.54E-07	4.10E-08	4.09E-08
SD13	76	9609	0.00E+00	3.58E-06	7.63E-06	1.49E-06	2.12E-04	0.00E+00	9.39E-07	5.08E-08	5.09E-08
SD13	77	9609	0.00E+00	2.68E-06	5.67E-06	1.13E-06	1.78E-04	0.00E+00	7.30E-07	4.10E-08	4.07E-08
SD13	78	9609	0.00E+00	3.34E-06	7.20E-06	1.37E-06	2.35E-04	0.00E+00	9.09E-07	5.03E-08	5.10E-08
SD13	79	9609	0.00E+00	2.68E-06	6.03E-06	1.07E-06	1.99E-04	0.00E+00	7.45E-07	4.10E-08	4.12E-08
SD13	80	9609	0.00E+00	3.52E-06	8.04E-06	1.25E-06	2.66E-04	0.00E+00	9.98E-07	5.22E-08	5.24E-08
SD13	81	9609	0.00E+00	2.92E-06	7.03E-06	1.07E-06	2.28E-04	0.00E+00	8.79E-07	4.28E-08	4.31E-08
SD13	82	9609	0.00E+00	3.64E-06	9.40E-06	1.19E-06	3.08E-04	0.00E+00	1.31E-06	5.54E-08	5.60E-08

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD13	83	9609	1.19E-07	3.10E-06	7.74E-06	9.54E-07	2.68E-04	3.73E-09	1.45E-06	4.61E-08	4.67E-08
SD13	84	9609	0.00E+00	3.93E-06	1.01E-05	1.19E-06	3.68E-04	0.00E+00	2.98E-06	6.01E-08	6.10E-08
SD13	85	9609	0.00E+00	3.22E-06	8.70E-06	8.34E-07	3.29E-04	0.00E+00	4.41E-06	4.98E-08	5.07E-08
SD13	86	9609	0.00E+00	4.35E-06	1.16E-05	1.13E-06	4.70E-04	0.00E+00	1.12E-05	6.47E-08	6.54E-08
SD13	87	9609	0.00E+00	4.11E-06	9.19E-06	8.34E-07	4.47E-04	0.00E+00	1.94E-05	5.31E-08	5.38E-08
SD13	88	9609	2.38E-07	5.25E-06	1.23E-05	1.67E-06	7.51E-04	0.00E+00	2.61E-01	6.98E-08	7.11E-08
SD13	89	9609	7.75E-07	3.40E-06	1.12E-05	2.92E-06	5.64E-04	3.73E-09	2.36E-01	6.10E-08	6.13E-08
SD13	90	9609	7.75E-07	4.47E-06	1.51E-05	2.80E-06	2.32E-04	0.00E+00	5.81E-02	7.50E-08	7.50E-08
SD13	91	9609	7.75E-07	4.89E-06	1.61E-05	2.92E-06	4.88E-05	7.45E-09	9.00E-03	7.17E-08	7.28E-08
SD13	92	9609	8.34E-07	8.23E-06	2.20E-05	3.04E-06	1.90E-05	1.86E-09	2.53E-03	9.36E-08	9.48E-08
SD13	93	9609	2.98E-07	7.39E-06	1.73E-05	1.67E-06	4.83E-06	3.73E-09	4.32E-04	7.08E-08	7.17E-08
SD13	94	9609	4.77E-07	1.04E-05	2.68E-05	2.15E-06	2.98E-06	7.45E-09	1.43E-04	1.05E-07	1.05E-07
SD13	95	9609	1.79E-07	8.64E-06	2.50E-05	1.31E-06	1.31E-06	3.73E-09	3.40E-05	8.61E-08	8.74E-08
SD13	96	9609	2.38E-07	1.11E-05	2.81E-05	1.31E-06	8.94E-07	9.31E-09	1.65E-05	1.08E-07	1.09E-07
SD13	97	9609	0.00E+00	8.88E-06	1.76E-05	8.34E-07	4.77E-07	3.73E-09	6.62E-06	8.52E-08	8.71E-08
SD13	98	9609	1.19E-07	1.14E-05	2.07E-05	9.54E-07	2.38E-07	7.45E-09	5.42E-06	1.08E-07	1.09E-07
SD13	99	9609	0.00E+00	9.48E-06	1.60E-05	7.75E-07	1.19E-07	9.31E-09	3.40E-06	8.52E-08	8.62E-08
SD13	100	9609	0.00E+00	1.23E-05	1.94E-05	8.34E-07	1.79E-07	3.73E-09	3.93E-06	1.05E-07	1.06E-07
SD13	101	9609	0.00E+00	9.95E-06	1.25E-05	6.56E-07	0.00E+00	5.59E-09	2.86E-06	7.12E-08	7.21E-08
SD13	102	9609	0.00E+00	1.38E-05	1.80E-05	7.15E-07	5.96E-08	5.59E-09	3.93E-06	9.83E-08	9.90E-08
SD13	103	9609	0.00E+00	1.16E-05	1.52E-05	5.96E-07	0.00E+00	5.59E-09	3.22E-06	8.01E-08	8.17E-08
SD13	104	9609	0.00E+00	1.50E-05	1.91E-05	7.15E-07	0.00E+00	7.45E-09	4.17E-06	1.01E-07	1.02E-07
SD13	105	9609	0.00E+00	1.27E-05	1.53E-05	6.56E-07	0.00E+00	3.73E-09	3.46E-06	8.10E-08	8.13E-08
SD13	106	9609	0.00E+00	1.67E-05	1.91E-05	6.56E-07	0.00E+00	9.31E-09	4.59E-06	9.87E-08	1.00E-07
SD13	107	9609	0.00E+00	1.39E-05	1.39E-05	6.56E-07	0.00E+00	1.86E-09	3.93E-06	7.26E-08	7.38E-08
SD13	108	9609	0.00E+00	1.76E-05	1.31E-05	6.56E-07	0.00E+00	1.86E-09	4.83E-06	7.45E-08	7.52E-08
SD13	109	9609	0.00E+00	1.32E-05	9.40E-06	6.56E-07	0.00E+00	3.73E-09	3.70E-06	5.54E-08	5.61E-08

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD13	110	9609	0.00E+00	1.51E-05	1.17E-05	6.56E-07	0.00E+00	1.86E-09	4.11E-06	6.80E-08	6.91E-08
SD13	111	9609	0.00E+00	1.21E-05	8.56E-06	5.36E-07	0.00E+00	3.73E-09	3.34E-06	5.12E-08	5.26E-08
SD13	112	9609	0.00E+00	1.63E-05	1.03E-05	6.56E-07	0.00E+00	0.00E+00	4.47E-06	6.19E-08	6.26E-08
SD13	113	9609	0.00E+00	1.45E-05	7.50E-06	4.77E-07	0.00E+00	0.00E+00	3.99E-06	4.61E-08	4.69E-08
SD13	114	9609	0.00E+00	1.99E-05	9.78E-06	6.56E-07	0.00E+00	1.86E-09	5.48E-06	6.01E-08	6.12E-08
SD13	115	9609	0.00E+00	1.73E-05	1.26E-05	4.77E-07	0.00E+00	1.86E-09	4.83E-06	6.47E-08	6.55E-08
SD13	116	9609	0.00E+00	2.25E-05	1.30E-05	6.56E-07	0.00E+00	3.73E-09	6.14E-06	6.85E-08	6.96E-08
SD13	117	9609	0.00E+00	1.96E-05	6.91E-06	4.77E-07	0.00E+00	1.86E-09	5.42E-06	4.42E-08	4.48E-08
SD13	118	9609	0.00E+00	2.68E-05	9.83E-06	5.36E-07	0.00E+00	0.00E+00	7.39E-06	6.19E-08	6.31E-08
SD13	119	9609	0.00E+00	2.34E-05	1.12E-05	4.77E-07	0.00E+00	5.59E-09	6.44E-06	6.43E-08	6.48E-08
SD13	120	9609	0.00E+00	3.06E-05	1.21E-05	5.96E-07	0.00E+00	1.86E-09	8.40E-06	7.31E-08	7.39E-08
SD13	121	9609	0.00E+00	2.62E-05	7.41E-06	4.17E-07	0.00E+00	3.73E-09	7.27E-06	4.89E-08	5.03E-08
SD13	122	9609	0.00E+00	3.56E-05	1.20E-05	5.96E-07	0.00E+00	1.86E-09	9.89E-06	7.50E-08	7.60E-08
SD13	123	9609	0.00E+00	2.98E-05	1.03E-05	4.77E-07	0.00E+00	5.59E-09	8.23E-06	6.33E-08	6.43E-08
SD13	124	9609	0.00E+00	3.85E-05	8.38E-06	5.36E-07	0.00E+00	1.86E-09	1.06E-05	5.96E-08	6.01E-08
SD13	125	9609	0.00E+00	3.33E-05	6.64E-06	3.58E-07	0.00E+00	0.00E+00	9.24E-06	4.66E-08	4.76E-08
SD13	126	9609	0.00E+00	4.44E-05	1.05E-05	5.96E-07	0.00E+00	1.86E-09	1.22E-05	6.85E-08	6.98E-08
SD13	127	9609	0.00E+00	3.71E-05	9.84E-06	3.58E-07	0.00E+00	5.59E-09	1.03E-05	6.24E-08	6.28E-08
SD13	128	9609	0.00E+00	4.82E-05	1.19E-05	4.77E-07	0.00E+00	3.73E-09	1.34E-05	7.54E-08	7.70E-08
SD13	129	9609	0.00E+00	4.01E-05	9.92E-06	4.77E-07	0.00E+00	3.73E-09	1.10E-05	6.29E-08	6.31E-08
SD13	130	9609	0.00E+00	5.19E-05	1.25E-05	4.17E-07	0.00E+00	3.73E-09	1.43E-05	7.78E-08	7.93E-08
SD13	131	9609	0.00E+00	4.30E-05	9.91E-06	4.17E-07	0.00E+00	3.73E-09	1.19E-05	6.19E-08	6.30E-08
SD13	132	9609	0.00E+00	5.54E-05	1.23E-05	4.77E-07	0.00E+00	5.59E-09	1.53E-05	7.73E-08	7.76E-08
SD13	133	9609	0.00E+00	4.58E-05	9.17E-06	3.58E-07	0.00E+00	3.73E-09	1.26E-05	5.82E-08	5.90E-08
SD13	134	9609	0.00E+00	5.92E-05	1.19E-05	4.77E-07	0.00E+00	1.86E-09	1.64E-05	7.40E-08	7.56E-08
SD13	135	9609	0.00E+00	4.86E-05	9.51E-06	3.58E-07	0.00E+00	5.59E-09	1.34E-05	5.96E-08	6.05E-08
SD13	136	9609	0.00E+00	6.20E-05	1.18E-05	3.58E-07	0.00E+00	1.86E-09	1.72E-05	7.36E-08	7.49E-08

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD13	137	9609	0.00E+00	5.08E-05	8.86E-06	3.58E-07	0.00E+00	5.59E-09	1.41E-05	5.73E-08	5.74E-08
SD13	138	9609	0.00E+00	6.47E-05	1.03E-05	4.77E-07	0.00E+00	1.86E-09	1.78E-05	6.66E-08	6.78E-08
SD13	139	9609	0.00E+00	5.33E-05	8.93E-06	4.17E-07	0.00E+00	3.73E-09	1.47E-05	5.63E-08	5.74E-08
SD13	140	9609	0.00E+00	6.74E-05	1.14E-05	3.58E-07	0.00E+00	3.73E-09	1.86E-05	7.22E-08	7.28E-08
SD13	141	9609	0.00E+00	5.45E-05	8.65E-06	3.58E-07	0.00E+00	3.73E-09	1.50E-05	5.49E-08	5.59E-08
SD13	142	9609	0.00E+00	6.90E-05	9.97E-06	4.77E-07	0.00E+00	1.86E-09	1.91E-05	6.47E-08	6.59E-08
SD13	143	9609	0.00E+00	5.63E-05	8.52E-06	2.98E-07	0.00E+00	1.86E-09	1.55E-05	5.45E-08	5.53E-08
SD13	144	9609	0.00E+00	7.01E-05	9.54E-06	3.58E-07	0.00E+00	3.73E-09	1.95E-05	6.33E-08	6.37E-08
SD13	145	9609	0.00E+00	5.72E-05	7.27E-06	3.58E-07	0.00E+00	1.86E-09	1.59E-05	4.80E-08	4.93E-08
SD13	146	9609	0.00E+00	7.25E-05	1.04E-05	3.58E-07	0.00E+00	5.59E-09	2.00E-05	6.71E-08	6.78E-08
SD13	147	9609	0.00E+00	5.79E-05	8.51E-06	2.98E-07	0.00E+00	1.86E-09	1.59E-05	5.45E-08	5.48E-08
SD13	148	9609	0.00E+00	7.24E-05	1.04E-05	4.77E-07	0.00E+00	3.73E-09	2.01E-05	6.61E-08	6.71E-08
SD13	149	9609	0.00E+00	5.71E-05	6.27E-06	2.98E-07	0.00E+00	1.86E-09	1.57E-05	4.38E-08	4.40E-08
SD13	150	9609	0.00E+00	7.27E-05	7.99E-06	3.58E-07	0.00E+00	1.86E-09	2.01E-05	5.45E-08	5.56E-08
SD13	151	9609	0.00E+00	5.40E-05	6.06E-06	2.98E-07	0.00E+00	0.00E+00	1.48E-05	4.19E-08	4.27E-08
SD13	152	9609	0.00E+00	2.44E-05	7.50E-06	3.58E-07	0.00E+00	3.73E-09	6.79E-06	5.17E-08	5.29E-08
SD13	153	9609	0.00E+00	7.03E-06	7.15E-06	2.98E-07	0.00E+00	1.86E-09	1.91E-06	4.75E-08	4.75E-08
SD13	154	9609	0.00E+00	5.78E-06	9.83E-06	3.58E-07	0.00E+00	3.73E-09	1.61E-06	6.19E-08	6.34E-08
SD13	155	9609	0.00E+00	3.93E-06	7.95E-06	2.98E-07	0.00E+00	1.86E-09	1.07E-06	5.08E-08	5.13E-08
SD13	156	9609	0.00E+00	4.89E-06	6.97E-06	3.58E-07	0.00E+00	1.86E-09	1.37E-06	4.89E-08	5.02E-08
SD13	157	9609	0.00E+00	4.23E-06	3.95E-06	2.98E-07	0.00E+00	0.00E+00	1.13E-06	3.26E-08	3.23E-08
SD13	158	9609	0.00E+00	5.60E-06	6.65E-06	3.58E-07	0.00E+00	3.73E-09	1.49E-06	4.70E-08	4.84E-08
SD13	159	9609	0.00E+00	4.35E-06	7.19E-06	2.98E-07	0.00E+00	1.86E-09	1.19E-06	4.70E-08	4.77E-08
SD13	160	9609	0.00E+00	5.07E-06	6.97E-06	3.58E-07	0.00E+00	0.00E+00	1.49E-06	4.94E-08	5.01E-08
SD13	161	9609	0.00E+00	4.23E-06	6.97E-06	1.79E-07	0.00E+00	3.73E-09	1.13E-06	4.61E-08	4.66E-08
SD13	162	9609	0.00E+00	5.13E-06	6.88E-06	3.58E-07	0.00E+00	1.86E-09	1.43E-06	4.84E-08	4.95E-08
SD13	163	9609	0.00E+00	4.17E-06	6.69E-06	1.79E-07	0.00E+00	1.86E-09	1.19E-06	4.47E-08	4.52E-08

Table A-2 Plume Segment Release Fractions (cont.)

STG	Plume Segment	MELCOR Pathway	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La
SD13	164	9609	0.00E+00	5.13E-06	6.57E-06	4.17E-07	0.00E+00	0.00E+00	1.37E-06	4.66E-08	4.77E-08
SD13	165	9609	0.00E+00	4.23E-06	3.06E-06	2.38E-07	0.00E+00	0.00E+00	1.19E-06	2.70E-08	2.74E-08
SD13	166	9609	0.00E+00	3.46E-06	2.15E-06	1.79E-07	0.00E+00	0.00E+00	8.34E-07	1.96E-08	1.97E-08

Table A-3 Chemical Group Release Fraction by Particle-Size Distribution

STG	Group	1	2	3	4	5	6	7	8	9	10
size (micron)		0.153	0.285	0.531	0.989	1.84	3.43	6.38	11.9	22.1	41.2
dp (micron)		0.153	0.285	0.531	0.989	1.84	3.43	6.38	11.9	20	41.2
SD01	Xe	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
SD01	Cs	1.48E-02	9.76E-03	2.79E-02	7.81E-02	1.58E-01	2.02E-01	1.74E-01	1.01E-01	3.18E-02	2.02E-01
SD01	Ba	1.23E-02	1.19E-02	3.56E-02	1.06E-01	2.21E-01	2.66E-01	1.93E-01	8.29E-02	3.02E-02	4.10E-02
SD01	I	1.86E-02	1.00E-02	2.46E-02	6.86E-02	1.42E-01	1.86E-01	1.74E-01	1.18E-01	4.06E-02	2.18E-01
SD01	Te	1.29E-02	1.03E-02	3.10E-02	8.75E-02	1.80E-01	2.22E-01	1.82E-01	9.40E-02	2.73E-02	1.53E-01
SD01	Ru	3.87E-02	1.67E-02	2.43E-02	5.18E-02	8.87E-02	1.21E-01	1.47E-01	1.37E-01	5.36E-02	3.21E-01
SD01	Mo	9.35E-04	4.91E-03	2.05E-02	6.11E-02	1.51E-01	2.25E-01	2.30E-01	1.74E-01	8.92E-02	4.29E-02
SD01	Ce	5.17E-02	1.95E-02	7.91E-03	3.43E-02	1.13E-01	1.96E-01	2.01E-01	1.79E-01	1.08E-01	8.91E-02
SD01	La	4.23E-02	1.75E-02	1.39E-02	5.07E-02	1.40E-01	2.14E-01	2.01E-01	1.58E-01	8.99E-02	7.28E-02
SD01-2	Xe	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
SD01-2	Cs	8.14E-03	2.68E-02	6.56E-02	1.72E-01	3.11E-01	2.62E-01	1.22E-01	2.72E-02	3.27E-03	1.24E-03
SD01-2	Ba	6.73E-03	2.26E-02	5.90E-02	1.57E-01	2.81E-01	2.52E-01	1.42E-01	5.79E-02	1.59E-02	5.52E-03
SD01-2	I	8.26E-03	2.70E-02	6.72E-02	1.78E-01	3.19E-01	2.59E-01	1.10E-01	2.52E-02	5.03E-03	1.68E-03
SD01-2	Te	7.82E-03	2.49E-02	6.25E-02	1.65E-01	3.02E-01	2.58E-01	1.27E-01	3.94E-02	9.34E-03	3.53E-03
SD01-2	Ru	1.76E-02	1.82E-02	4.52E-02	1.21E-01	2.18E-01	2.03E-01	1.40E-01	8.07E-02	2.57E-02	1.31E-01
SD01-2	Mo	1.44E-03	5.81E-03	1.59E-02	4.73E-02	1.37E-01	2.26E-01	2.38E-01	1.92E-01	1.00E-01	3.58E-02
SD01-2	Ce	9.84E-03	1.81E-02	5.06E-02	1.38E-01	2.59E-01	2.48E-01	1.60E-01	8.00E-02	2.35E-02	1.36E-02
SD01-2	La	7.62E-03	2.20E-02	5.84E-02	1.56E-01	2.83E-01	2.54E-01	1.44E-01	5.70E-02	1.32E-02	5.45E-03
SD01-8	Xe	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
SD01-8	Cs	6.84E-03	3.15E-02	8.87E-02	2.42E-01	3.95E-01	1.95E-01	3.50E-02	4.46E-03	5.31E-04	6.40E-04
SD01-8	Ba	6.26E-03	3.11E-02	8.75E-02	2.43E-01	3.75E-01	1.96E-01	4.97E-02	1.03E-02	1.04E-03	2.10E-04
SD01-8	I	6.55E-03	3.10E-02	8.69E-02	2.36E-01	3.85E-01	2.01E-01	4.49E-02	7.49E-03	7.93E-04	1.89E-04
SD01-8	Te	6.80E-03	2.95E-02	8.07E-02	2.14E-01	3.82E-01	2.18E-01	5.21E-02	1.38E-02	2.49E-03	6.16E-04
SD01-8	Ru	1.67E-02	2.55E-02	7.00E-02	1.88E-01	2.81E-01	1.56E-01	7.23E-02	5.37E-02	2.02E-02	1.17E-01
SD01-8	Mo	1.28E-03	6.58E-03	1.79E-02	4.61E-02	1.71E-01	3.40E-01	2.71E-01	1.21E-01	2.37E-02	1.83E-03
SD01-8	Ce	1.14E-02	3.01E-02	8.30E-02	2.20E-01	3.56E-01	2.11E-01	6.30E-02	1.60E-02	4.82E-03	4.66E-03
SD01-8	La	7.53E-03	3.01E-02	8.64E-02	2.30E-01	3.65E-01	2.10E-01	5.85E-02	1.06E-02	1.11E-03	1.69E-04

Table A-3 Chemical Group Release Fraction by Particle-Size Distribution (cont.)

STG	Group	1	2	3	4	5	6	7	8	9	10
size (micron)		0.153	0.285	0.531	0.989	1.84	3.43	6.38	11.9	22.1	41.2
dp (micron)		0.153	0.285	0.531	0.989	1.84	3.43	6.38	11.9	20	41.2
SD03	Xe	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
SD03	Cs	1.42E-01	2.05E-02	1.35E-02	5.51E-02	1.32E-01	1.71E-01	1.85E-01	1.65E-01	8.56E-02	3.02E-02
SD03	Ba	2.47E-01	4.47E-02	9.52E-03	3.96E-02	1.02E-01	1.39E-01	1.60E-01	1.50E-01	7.92E-02	2.91E-02
SD03	I	1.49E-01	2.08E-02	1.26E-02	5.02E-02	1.24E-01	1.67E-01	1.88E-01	1.69E-01	8.77E-02	3.19E-02
SD03	Te	1.64E-01	2.25E-02	1.04E-02	4.46E-02	1.14E-01	1.59E-01	1.86E-01	1.73E-01	9.22E-02	3.46E-02
SD03	Ru	8.41E-02	9.51E-03	1.21E-02	5.69E-02	1.50E-01	1.94E-01	2.01E-01	1.74E-01	8.91E-02	2.96E-02
SD03	Mo	1.55E-01	2.09E-02	1.19E-02	4.72E-02	1.17E-01	1.62E-01	1.88E-01	1.74E-01	9.06E-02	3.30E-02
SD03	Ce	2.18E-03	2.53E-03	2.47E-02	1.06E-01	2.28E-01	2.40E-01	1.85E-01	1.32E-01	6.38E-02	1.54E-02
SD03	La	1.17E-02	4.89E-03	3.00E-02	1.00E-01	2.12E-01	2.41E-01	2.02E-01	1.36E-01	5.15E-02	1.03E-02
SD05	Xe	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
SD05	Cs	2.10E-02	1.97E-02	8.97E-02	2.46E-01	3.59E-01	1.93E-01	4.61E-02	9.31E-03	3.00E-03	1.36E-02
SD05	Ba	4.60E-02	1.14E-02	6.80E-02	1.97E-01	3.54E-01	2.33E-01	6.76E-02	1.47E-02	2.85E-03	5.87E-03
SD05	I	1.91E-02	2.22E-02	9.21E-02	2.40E-01	3.52E-01	1.97E-01	4.98E-02	1.06E-02	3.33E-03	1.40E-02
SD05	Te	2.09E-02	2.35E-02	9.58E-02	2.43E-01	3.52E-01	1.91E-01	4.58E-02	9.40E-03	3.20E-03	1.49E-02
SD05	Ru	1.09E-02	2.77E-02	9.08E-02	2.29E-01	3.43E-01	2.04E-01	5.40E-02	1.27E-02	5.31E-03	2.26E-02
SD05	Mo	1.78E-02	2.11E-02	9.16E-02	2.51E-01	3.60E-01	1.88E-01	4.32E-02	8.60E-03	3.14E-03	1.54E-02
SD05	Ce	6.85E-04	6.13E-03	4.41E-02	1.88E-01	3.75E-01	2.68E-01	9.34E-02	2.15E-02	2.72E-03	2.02E-04
SD05	La	3.94E-03	3.76E-02	1.52E-01	2.65E-01	2.93E-01	1.76E-01	5.72E-02	1.29E-02	1.71E-03	8.35E-04
SD07	Xe	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
SD07	Cs	4.55E-02	1.85E-02	7.56E-02	1.79E-01	2.77E-01	2.33E-01	1.08E-01	4.22E-02	1.24E-02	9.89E-03
SD07	Ba	1.90E-02	2.15E-02	7.03E-02	1.40E-01	2.81E-01	2.86E-01	1.27E-01	4.10E-02	9.74E-03	3.96E-03
SD07	I	2.86E-02	1.41E-02	8.45E-02	2.18E-01	2.85E-01	2.16E-01	9.92E-02	3.80E-02	1.02E-02	6.02E-03
SD07	Te	2.71E-02	5.88E-02	2.27E-01	2.92E-01	1.97E-01	1.10E-01	5.20E-02	2.32E-02	7.22E-03	5.56E-03
SD07	Ru	4.69E-02	1.08E-02	8.35E-02	2.38E-01	2.66E-01	1.77E-01	1.00E-01	5.03E-02	1.34E-02	1.44E-02
SD07	Mo	2.81E-03	5.69E-03	1.94E-02	3.70E-02	1.32E-01	2.58E-01	2.48E-01	1.78E-01	9.21E-02	2.73E-02
SD07	Ce	9.36E-03	8.41E-03	2.72E-02	1.09E-01	3.08E-01	3.32E-01	1.47E-01	4.52E-02	1.01E-02	4.54E-03
SD07	La	1.18E-02	7.95E-02	2.09E-01	2.04E-01	2.04E-01	1.74E-01	7.99E-02	2.88E-02	7.66E-03	2.17E-03
SD08-2	Xe	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01

Table A-3 Chemical Group Release Fraction by Particle-Size Distribution (cont.)

STG	Group	1	2	3	4	5	6	7	8	9	10
size (micron)		0.153	0.285	0.531	0.989	1.84	3.43	6.38	11.9	22.1	41.2
dp (micron)		0.153	0.285	0.531	0.989	1.84	3.43	6.38	11.9	20	41.2
SD08-2	Cs	9.89E-02	1.70E-01	1.09E-01	1.43E-01	3.24E-01	1.37E-01	1.31E-02	2.56E-03	9.93E-04	9.80E-04
SD08-2	Ba	6.77E-02	1.83E-01	1.59E-01	1.48E-01	3.00E-01	1.33E-01	8.75E-03	5.35E-04	1.22E-04	9.66E-05
SD08-2	I	1.07E-01	2.21E-01	1.50E-01	1.49E-01	2.56E-01	1.05E-01	9.36E-03	1.73E-03	7.04E-04	7.03E-04
SD08-2	Te	1.07E-01	2.95E-01	2.48E-01	1.39E-01	1.47E-01	5.70E-02	5.17E-03	9.86E-04	3.74E-04	3.63E-04
SD08-2	Ru	6.11E-02	1.19E-01	9.77E-02	1.98E-01	3.58E-01	1.49E-01	1.29E-02	2.16E-03	5.67E-04	2.59E-04
SD08-2	Mo	7.06E-02	3.24E-01	3.72E-01	1.47E-01	6.32E-02	2.09E-02	1.77E-03	3.47E-04	1.30E-04	1.25E-04
SD08-2	Ce	1.17E-02	3.28E-02	3.95E-02	1.49E-01	5.13E-01	2.37E-01	1.53E-02	7.67E-04	1.11E-04	5.82E-05
SD08-2	La	8.55E-02	2.06E-01	1.61E-01	1.37E-01	2.77E-01	1.24E-01	7.94E-03	3.97E-04	6.24E-05	2.87E-05
SD09	Xe	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
SD09	Cs	1.13E-01	4.07E-03	1.82E-02	9.50E-02	2.05E-01	1.73E-01	1.77E-01	1.47E-01	5.60E-02	1.19E-02
SD09	Ba	2.14E-01	8.11E-03	1.45E-02	7.71E-02	1.70E-01	1.54E-01	1.68E-01	1.34E-01	5.00E-02	1.07E-02
SD09	I	1.13E-01	4.03E-03	2.06E-02	9.56E-02	1.93E-01	1.70E-01	1.82E-01	1.52E-01	5.75E-02	1.26E-02
SD09	Te	1.25E-01	4.46E-03	1.61E-02	8.48E-02	1.88E-01	1.67E-01	1.83E-01	1.57E-01	6.17E-02	1.41E-02
SD09	Ru	4.53E-02	1.36E-03	1.97E-02	1.08E-01	2.38E-01	1.81E-01	1.75E-01	1.58E-01	6.04E-02	1.21E-02
SD09	Mo	1.31E-01	4.70E-03	1.46E-02	7.99E-02	1.81E-01	1.65E-01	1.85E-01	1.60E-01	6.36E-02	1.48E-02
SD09	Ce	8.24E-03	1.31E-04	3.28E-02	1.57E-01	2.99E-01	2.08E-01	1.52E-01	1.08E-01	3.24E-02	2.63E-03
SD09	La	2.68E-02	9.51E-04	4.79E-02	1.68E-01	2.44E-01	1.99E-01	1.71E-01	1.11E-01	2.84E-02	2.37E-03
SD11-1	Xe	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
SD11-1	Cs	1.04E-01	9.25E-02	4.37E-02	1.99E-02	9.46E-02	2.04E-01	2.06E-01	1.43E-01	7.20E-02	1.90E-02
SD11-1	Ba	3.63E-02	6.16E-02	4.62E-02	2.90E-02	1.12E-01	2.87E-01	2.31E-01	1.33E-01	5.29E-02	1.11E-02
SD11-1	I	5.74E-02	6.60E-02	4.05E-02	3.28E-02	1.29E-01	2.58E-01	2.16E-01	1.28E-01	5.86E-02	1.44E-02
SD11-1	Te	6.66E-02	6.99E-02	4.04E-02	3.11E-02	1.26E-01	2.60E-01	2.11E-01	1.23E-01	5.78E-02	1.46E-02
SD11-1	Ru	6.75E-02	9.02E-02	5.52E-02	1.61E-02	6.52E-02	1.95E-01	2.26E-01	1.73E-01	8.92E-02	2.31E-02
SD11-1	Mo	7.71E-02	6.65E-02	3.16E-02	2.14E-02	1.16E-01	2.69E-01	2.26E-01	1.23E-01	5.48E-02	1.48E-02
SD11-1	Ce	1.61E-03	3.23E-03	1.03E-02	6.15E-02	2.26E-01	3.25E-01	2.11E-01	9.92E-02	3.15E-02	3.15E-02
SD11-1	La	8.77E-03	1.53E-02	1.72E-02	4.80E-02	2.16E-01	4.14E-01	2.00E-01	5.72E-02	1.79E-02	6.30E-03
SD12	Xe	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
SD12	Cs	8.19E-02	5.46E-02	3.26E-02	5.43E-02	9.07E-02	1.24E-01	1.54E-01	1.63E-01	1.16E-01	1.29E-01

Table A-3 Chemical Group Release Fraction by Particle-Size Distribution (cont.)

STG	Group	1	2	3	4	5	6	7	8	9	10
size (micron)		0.153	0.285	0.531	0.989	1.84	3.43	6.38	11.9	22.1	41.2
dp (micron)		0.153	0.285	0.531	0.989	1.84	3.43	6.38	11.9	20	41.2
SD12	Ba	1.21E-01	6.80E-02	3.42E-02	6.96E-02	1.04E-01	1.25E-01	1.40E-01	1.48E-01	1.04E-01	8.64E-02
SD12	I	1.28E-01	9.58E-02	4.46E-02	5.17E-02	7.92E-02	1.06E-01	1.32E-01	1.42E-01	1.01E-01	1.21E-01
SD12	Te	1.35E-01	9.96E-02	4.43E-02	4.96E-02	7.60E-02	1.03E-01	1.31E-01	1.41E-01	1.02E-01	1.18E-01
SD12	Ru	5.79E-02	3.83E-02	2.97E-02	5.21E-02	8.86E-02	1.27E-01	1.65E-01	1.79E-01	1.29E-01	1.33E-01
SD12	Mo	7.30E-02	4.86E-02	3.17E-02	5.23E-02	8.90E-02	1.25E-01	1.58E-01	1.67E-01	1.20E-01	1.35E-01
SD12	Ce	2.09E-01	1.35E-01	4.69E-02	8.39E-02	1.09E-01	9.38E-02	8.64E-02	9.99E-02	7.57E-02	5.96E-02
SD12	La	3.94E-01	3.25E-01	9.26E-02	3.24E-02	2.56E-02	2.22E-02	2.50E-02	3.56E-02	2.82E-02	1.93E-02
SD13	Xe	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
SD13	Cs	1.49E-02	2.65E-03	1.74E-02	1.13E-01	2.76E-01	3.07E-01	1.85E-01	6.59E-02	1.42E-02	3.86E-03
SD13	Ba	4.28E-03	9.54E-03	3.44E-02	1.13E-01	2.96E-01	2.92E-01	1.48E-01	6.33E-02	2.58E-02	1.31E-02
SD13	I	1.30E-02	1.91E-03	1.58E-02	1.08E-01	2.72E-01	3.10E-01	1.91E-01	6.90E-02	1.52E-02	4.44E-03
SD13	Te	1.29E-02	4.90E-03	2.30E-02	1.11E-01	2.70E-01	3.02E-01	1.87E-01	6.93E-02	1.54E-02	4.33E-03
SD13	Ru	6.25E-03	1.11E-03	1.15E-02	1.07E-01	3.04E-01	3.02E-01	1.77E-01	7.03E-02	1.59E-02	4.92E-03
SD13	Mo	4.06E-03	3.54E-03	1.08E-02	4.75E-02	1.72E-01	2.86E-01	2.46E-01	1.52E-01	6.35E-02	1.43E-02
SD13	Ce	1.61E-04	1.69E-03	1.39E-02	9.85E-02	3.13E-01	3.09E-01	1.53E-01	6.73E-02	2.88E-02	1.46E-02
SD13	La	1.45E-03	1.14E-02	3.49E-02	1.05E-01	2.96E-01	2.95E-01	1.48E-01	6.60E-02	2.84E-02	1.45E-02

NRC FORM 335
(12-2010)
NRCMD 3.7

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER
(Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.)

NUREG-XXXX

2. TITLE AND SUBTITLE

U.S. NRC Level 3 Probabilistic Risk Assessment Project

Volume 5c: Reactor, At-Shutdown, Level 3 PRA for Internal Events

3. DATE REPORT PUBLISHED

MONTH	YEAR
September	**2025**

4. FIN OR GRANT NUMBER

5. AUTHOR(S)

Keith Compton
Alfred (Trey) Hathaway
Alan Kuritzky

6. TYPE OF REPORT

Technical

7. PERIOD COVERED (Inclusive Dates)

8. PERFORMING ORGANIZATION - NAME AND ADDRESS (If NRC, provide Division, Office or Region, U. S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)

Division of Systems Analysis and Division of Risk Analysis
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

9. SPONSORING ORGANIZATION - NAME AND ADDRESS (If NRC, type "Same as above", if contractor, provide NRC Division, Office or Region, U. S. Nuclear Regulatory Commission, and mailing address.)

Same as above

10. SUPPLEMENTARY NOTES

11. ABSTRACT (200 words or less)

The U.S. Nuclear Regulatory Commission performed a full-scope site Level 3 probabilistic risk assessment (PRA) project (L3PRA project) for a two-unit pressurized-water reactor reference plant. The scope of the L3PRA project encompasses all major radiological sources on the site (i.e., reactors, spent fuel pools, and dry cask storage), all internal and external hazards, and all modes of plant operation. A full-scope site Level 3 PRA for a nuclear power plant site can provide valuable insights into the importance of various risk contributors by assessing accidents involving one or more reactor cores as well as other site radiological sources. This report, one of a series of reports documenting the models and analyses supporting the L3PRA project, specifically addresses the reactor, at-shutdown, Level 3 PRA model for internal events for a refueling outage for a single unit. The analyses documented herein are based information for the reference plant as it was designed and operated as of 2012 and does not reflect the plant as it is currently designed, licensed, operated, or maintained.

12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.)

PRA
Low Power
Shutdown
Level 3 PRA
Level 3 PRA project
L3PRA project
Risk
Consequences

13. AVAILABILITY STATEMENT

unlimited

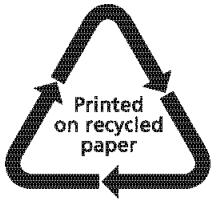
14. SECURITY CLASSIFICATION

(This Page)
unclassified

(This Report)
unclassified

15. NUMBER OF PAGES

16. PRICE



Federal Recycling Program

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, DC 20555-0001

OFFICIAL BUSINESS